MATHEMATICS

Guidebook for Undergraduate Math Majors

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SECTION 1. INTRODUCTION

Mathematics is classified both with the humanities and the sciences. Its position among the humanities is based on the study of mathematics as one of the liberal arts for more than 2000 years. Still very much an expanding subject, mathematics offers more new and challenging frontiers than at any time in its long history – with totally new mathematical fields requiring new techniques and ideas for exploration.

The basic principles of engineering and the natural sciences have for centuries been stated and studied in terms of mathematics. More recently, mathematics has become an indispensable tool in every technical science.

Consequently students may wish to major in mathematics for many different reasons and the math major requirements are flexible enough to accommodate a wide range of programs. Some students who major in mathematics may wish simply to pursue their enjoyment and interest in mathematics. Others may have some particular goals in mind such as preparation for graduate work in mathematics, or for specific jobs, or for further study in some other areas in which mathematics may be used to advantage.

Various opportunities open to math majors after graduation are discussed in Section 2. The math major requirements are stated in Section 3. There is a suggested program for preparation for graduate study in mathematics and there are sample programs in which the math major courses are directed toward various fields of application. These include:

Computer Sciences	Meteorology
Chemistry	Economics
Physics	Genetics
Statistics	Ecology
Actuarial Mathematics	Forestry
Engineering	Business

In Section 4 some activities and facilities of special interest to undergraduate math majors are discussed. Section 5 provides information about other undergraduate programs closely related to the mathematics major.

SECTION 2. OPPORTUNITIES AFTER GRADUATION

While the main motivation to choose math as a major should stem from a combination of keen interest and high ability in math, the student is naturally concerned about the opportunities available after graduation. At this time, the math major appears to be in a better position than many other majors for employment in business, industry, governmental agencies, and teaching. The prospects are also good for well-qualified students to obtain support for graduate studies in mathematics. Also a major in mathematics is excellent preparation for further study in many other fields.

These websites offer information on career opportunities as well as various career profiles:

www.awm-math.org — Association for Women in Mathematics
www.awm-math.org/ctcbrochure/toc.html — online version of "Careers that Count"

www.maa.org — Mathematical Association of America
www.maa.org/careers/index.html — numerous career profiles

http://math.uga.edu/~shifrin/jobops.html — University of Georgia
links to nonacademic job opportunities

www.ams.org/employment — American Mathematical Society web page

The following pamphlets contain useful information about careers for math majors. Copies are available for inspection through the Undergraduate Program Assistant in Room 218 Van Vleck.

1) Mathematical Scientists at Work: These are essays about people working as mathematicians in a variety of jobs. Careers in the Mathematical Sciences and More Careers in the Mathematical Sciences contain shorter essays and a list of sources in additional information. The Mathematical Association of America, 1529 Eighteenth St., NW, Washington, D.C. 20036.

2) Seeking Employment in the Mathematical Sciences, American Mathematical Society, P.O. Box 1571, Annex Station, Providence, R.I. 02901.

3) Careers in Applied Mathematics, SIAM (Society for Industrial and Applied Mathematics), 3600 University City Science Center, Philadelphia, PA 19104.

Also recommended: the books 101 Careers in Mathematics, Andrew Sterrett, Ed., and She Does Math! Real-life Problems from Women on the Job, Marla Parker, Ed., both from Mathematical Association of America, PO Box 91112, Washington, D.C. 20090-1112.

BUSINESS, INDUSTRY AND GOVERNMENT

The prospects for opportunities for math majors in business, industry and government have been good over the years although there has been, of course, some variation depending on the general economic situation. In some cases employers, having found math majors generally bright and flexible, desire them for positions which may involve considerable training on the job but perhaps not much direct use of their mathematical knowledge. In other positions math majors may make considerable use of their backgrounds in math, computer science, statistics or science. The possibilities range from positions in management to jobs as programmers, actuaries, or information systems consultants. To make their college backgrounds most valuable, math majors headed for business, industry or government should combine their math programs with courses in some related fields such as economics, sociology, psychology, business, computer sciences, statistics, or the physical and biological sciences. Some companies and agencies especially look for background in computer sciences and/or statistics. The Career Advising and Planning Office, 1305 Linden Dr. Suite 205, provides students with career and job

information, assists students in planning the job search and arranges interviews with visiting employer representatives. Also the facilities of the Business Career Center, 3290 Grainger Hall, are available to non-Business students.

TEACHING AT THE SECONDARY SCHOOL LEVEL

There is currently a strong demand for high school math teachers and there is some expectation that this demand will continue for some time.

As preparation the qualified student may enter the School of Education at the beginning of the junior year and complete a math major with course requirements somewhat different from the Letters and Science math major requirements. The requirements are outlined in Section 5 of this Guidebook. Upon successful completion of the Secondary Education Math Program the student is recommended for secondary school teacher certification in mathematics.

It is possible to complete the requirements for secondary school teacher certification in mathematics after earning an L&S degree with a math major. However the undergraduate SED math majors have priority in the certification program so some years there may be limitations on the number of post-graduate students accepted into the program.

The services of the Educational Placement and Career Services, B150 Education Building, are available to those seeking teaching positions at all levels in the U.S. and abroad.

TEACH FOR AMERICA

This program is dedicated to teaching in under-funded urban and rural schools and is especially interested in recruiting math majors. Teacher certification is not required. Information is available at the Career Advising and Planning Office or at www.teachforamerica.org.

PEACE CORPS

There are usually opportunities to teach mathematics at various levels through the Peace Corps. Often teaching credentials are not required. Information is available at the Career Advising and Placement Office at 1305 Linden Dr. Suite 205 or from the Peace Crops Recruiting Office, 240 Ag. Hall.

GRADUATE STUDIES IN OTHER FIELDS

An undergraduate math major is often good background for graduate work in other fields that use mathematics, such as computer sciences, statistics, medicine, economics, industrial engineering, operations research, genetics, forestry, educational psychology, meteorology, physics, and various other fields in the social, biological, and physical sciences. Of course, preparation for graduate work in one of these fields may also require a substantial number of courses more directly related to the field; however, some of these graduate programs accept math majors who have limited background in the area of study.

GRADUATE STUDIES IN MATHEMATICS

There are many opportunities for well-qualified students to obtain support for graduate studies in mathematics (see the next paragraph). The academic job market for Math Ph.D.'s is not very robust at this time. There always are jobs for graduates with above-average success in their teaching and research experiences. Some Math Ph.D.'s have obtained non-academic jobs doing consulting or research.

APPLYING FOR GRADUATE STUDIES IN MATHEMATICS

Normally the student should apply in the fall of the senior year for admission the following fall. Most math departments with graduate programs offer support for graduate study on a competitive basis in the form of teaching assistantships, research assistantships or fellowships. Students should apply to departments of varying quality to better their chances of admission and/or support. Usually letters of recommendation and results of the GRE (Graduate Record Examination) are required. Some, if not all, of these letters should be from math faculty who know the student's work in advanced math courses. Normally, students should plan to take the GRE General Test and the GRE Mathematics Subject Test in the fall of the senior year. The fall dates are usually in October and December. In some cases it is important to take the October test to be sure the results arrive in time for the student to get full consideration for admission and/or support. Information and application booklets for the GRE are available at the Graduate School Fellowship Office, in Bascom Hall or visit www.gre.org. Also at that office there is information about national competitive fellowships. A copy of an information booklet about the GRE Mathematics Subject Test is available for inspection in Room 218 Van Vleck.

Students considering graduate work in mathematics should feel free to ask faculty members about various math departments and graduate programs. The following also should be useful sources of information about graduate programs.

SOURCES OF INFORMATION ABOUT GRADUATE PROGRAMS IN MATHEMATICS

1) Assistantships and Fellowships in the Mathematical Sciences. This is published every fall. It lists the assistantships and fellowships available for the following academic year. Copies of this issue are available for inspection in Room 218 Van Vleck and in the Mathematics Library, Room B224, Van Vleck. A copy may be purchased from the American Mathematical Society, P.O. Box 6248, Providence, R.I. 02940

2) Two other sources for information on graduate programs are:

   The Ph.D. General Information and Customized Rankings at www.phds.org/ratings/. Data collected by the National Research Council.

   Peterson Guide to Graduate Programs in the Physical Sciences, Mathematics, found in the Math Library, B224 Van Vleck or at www.petersons.com.

3) Some announcements about graduate programs are posted on the bulletin boards on the second floor of Van Vleck. Others are available by the Undergraduate Advisor's office in room 309 Van Vleck.

SECTION 3. UNDERGRADUATE MATH MAJOR REQUIREMENTS IN THE COLLEGE OF LETTERS AND SCIENCE

PREPARATION AND ACCEPTANCE REQUIREMENTS

The student intending to major in math should complete the basic calculus sequence, Math 221, 222, 234 or the Honors sequence, Math 275, 276, 375, 376. A student taking the Honors sequence can declare their major after completing Math 375. Normally the basic 221-234 sequence is followed by Math 340, Elementary Matrix and Linear Algebra or Math 341, linear algebra. The second one prepares the student better for 500 level math courses and is labeled as an Honors class; the Math 375 course also covers linear algebra. Although a grade-point average of at least 2.5 in the calculus sequence is required for acceptance as a math major, normally a student should have a higher average to attempt a major in mathematics, since many students find some of the advanced math courses much more difficult than the beginning calculus sequence.

MATH MAJOR ADVISORS, 2009 - 2010

Professor Sergey Bolotin, Room 621 Van Vleck
Professor Marty Isaacs, Room 311 Van Vleck
Professor Alexandru Ionescu, Room 619 Van Vleck (Advising Chair)
Professor Gloria Marí Beffa, Room 309 Van Vleck (Honors advisor)
Professor Gabriele Meyer, Room 720 Van Vleck
Professor Joel Robbin, Room 313 Van Vleck
Professor Paul Terwilliger, Room 101A Van Vleck

ADVISING PROCEDURES, MAJOR DECLARATION, MATH MAJOR APPROVAL FORM

After completing Math 234 or 375, the student who intends to become a math major should obtain a math advisor through the Undergraduate Program Assistant in Room 218 Van Vleck. At that time the student should bring university transcripts for the department records. Students may obtain campus transcripts at the Peterson Building and transfer students may obtain copies of transcripts from their previous universities or colleges at the academic dean's office of their Madison campus college or school. If the student is eligible to major in mathematics, the student and the advisor should then complete the **Major Declaration Form**. As soon as appropriate, but normally not later than the beginning of the senior year, the math major must have the math advisor complete the **Math Major Approval Form**. This indicates which of the major requirements the student will follow.

More importantly, since the math major requirements allow considerable flexibility, students should plan their advanced math programs with the advice of their math advisors. Indeed, students who follow

Option II of the non-honors math major requirements must have the courses in their math programs formally approved by their math advisors.

MATH MAJORS NOT IN THE COLLEGE OF LETTERS AND SCIENCE

Such students may complete the math major and have this fact noted on the transcript. However the math major will not serve as a substitute for a major in the college or school from which the student will earn a degree.

Procedure for Students not in L&S. The student must obtain approval from the Math Department and the appropriate dean of the student's college. The Major Declaration Form signed by the math advisor is evidence of approval by the Math Department. The student's copy of this form may be used when seeking the dean's approval. The advising procedures and the major requirements as outlined in this section should be followed. Also the general major requirements of the College of Letters and Science must be satisfied. These include the following residency and GPA requirements.

1) At least 15 advanced credits in Math courses number above 306 (but not including Math 425) must be taken on this campus (the other required advanced Math credits for the major may be transfer credits);

2) A grade point average of at least 2.0 in all courses in the major and in the advanced Math courses in the major. (Note: Math 425 is **not** an Advanced-level course.)

*A note about retaking courses: If a student earns a D (or higher) in an upper-level course and wishes to retake the course as a refresher, the new grade will NOT be counted towards the *major and upper-level GPAs* (it does not average), but it will count towards the general GPA. If the student earns an F, credit is not assigned and the student needs to retake the course to earn credit. In this case the new grade does average.

Math majors not earning their degrees in the College of Letters and Science are not required to satisfy the general Letters and Science Degree requirements. Of course the requirements of the college or school in which the student is earning a degree must be followed.

MAJOR REQUIREMENTS: NON-HONORS

The student chooses one of two options. While Option II emphasizes the applications of mathematics, students following Option l are also encouraged to take courses in other departments that involve the application of mathematics.

OPTION l

Seven Mathematics courses numbered above 306, excluding Math 425 and Math 490. These seven courses must include:

1) Math 320 or Math 340 or Math 341 or Math 375 (Math 341 is strongly recommended, Math 320 is not recommended although accepted in some circumstances), and

2) **Three courses** numbered above 500 including **at least two** of the following: 521, 541, 551. No more than three credits from Math 699 can be counted toward the satisfaction of the Option 1 requirements.

Students are strongly recommended to take either Math 341 or Math 421 before advancing into courses numbered above 500. These form the so called "bridge courses" that allow students to develop additional mathematical maturity and that put emphasis on the writing of proofs. Other courses that include an emphasis on writing proofs, and which are at a similar level, include Math 461 and Math 371.

In order to have breadth in the Math major program, it is recommended that students take **at least one** course from **each of at least two of the following groups:**

a) 461, 552, 561, 565
b) 321, 522, 623, 629
c) 319, 322, 415, 519
d) 309, 310, 431, 632
e) 443, 542, 567
f) 571
g) 435, 475
h) 513, 514, 525

Recommendation for students preparing for graduate work in mathematics: satisfy 1, 2 and 3 below:

1) 340, 521, 522, 541, 542
2) 551 or 561
3) At least one course from each of at least two of the following groups:
    i) 623, 629
    ii) 571
    iii) 322, 415, 519
    iv) 309, 310, 431, 632
    v) 435, 475
    vi) 513, 514, 525

OPTION ll: (For students interested in a particular area of application)

a) **Four** courses in some area of application of mathematics, **including at least three courses at the intermediate or advanced level,** selected with the approval of the student's math advisor

AND

b) **Six Mathematics courses numbered above 306,** excluding Math 425 and 490. These six courses must be approved by the student's math advisor and **must include:**

    1) Math 320 or 340 or 341 or 375

and

2) At least two courses numbered above 500

No courses may be used to fulfill both a) and b).

Approval of a program for Option II will be required before a significant part of the program is completed and changes in the approved program will require prior consent of the student's math advisor. The program is formally approved on the Math Major Approval Form, a copy of which is sent to the Degree Summary Office.

SAMPLE PROGRAMS FOR OPTION II (pages 11-14)

A suitable program for Option II should be a coherent plan of courses in Math and the area of application. While part (a) may include background courses, it must include courses in the area of application that makes significant use of mathematics. The Math courses in part (b) should include courses that are pertinent to these applications.

The sample programs on pages 11-14 show the types of programs that are suitable for Option ll; however, students are encouraged to develop programs that are best suited to their individual needs and interests. **Normally a program must include at least one of Math 521 or Math 541.**

A student who wishes to satisfy Option II must have the student's math advisor approve a program on the Math Major Approval Form even when the program is one of the sample programs. Note that on some of the sample programs the student will need a strong background in the applications area (such in the case for the chemical engineering option for example).

Note: Some of the courses not in L&S listed in Part (a) of these sample programs will not count for degree credit in the College of Letters and Science. Courses not in L&S that do not count are followed by (N) and those that do are followed by (T). An L&S student may count up to twenty credits in (T) courses toward an L&S degree. When (N) courses are used to satisfy the Option II math major requirements the math advisor must recommend such to an L&S Dean of Student Academic Affairs even when the student is earning a degree outside the College of Letters and Science. Note that even when an (N) course is approved for Part (a) of Option II it does not count toward the 120 credits required for an L&S degree.

UNDERGRADUATE RESEARCH

The following is the updated web page containing all the information about undergraduate research in the Math department at UW-Madison: http://www.math.wisc.edu/%7Emaribeff/UResearch/

For more information, see the Honors advisor.

Sample Programs for Option II of the Math Major Requirements

AREA OF APPLICATION	PART (a): COURSES IN THE AREA OF APPLICATION	PART (b): MATH COURSES
Actuarial Mathematics	• Act. Sci. 650(T), 651(T), 652(T) • Math 303	• Math 309, 310, 340, 521, 632 • 1 of the following: 431, 443, 522, 525
Atmospheric & Oceanic Sci. (Previously Meteorology)	• ATM OCN 310, 311, 330 • Physics 208	• Math 319, 322, 514, 521 • either 320 or 340 • either 321 or 522 (Note that 321 is ordinarily a prerequisite for 322.)
Bio-Informatics	• BMI 576 • CS 302, 367 • GEN 466	• Math 340, 431, 475, 514, 525 • either 443 or 513 (Note that 431 can be replaced with 309-10, but the total number of courses will go up to 7. Math 521 is recommended for students planning to go to Graduate School.)
Bio-Statistics	• Stats 333, 424, 575, either 641 or 642 • should consider 541 if going to Medical School	• Math 309, 310, 340, 521 • either 443 or 513 • either 525 or 632
Business (Operations Research)	• Math 525 • OIM 410(T), 411(T) • 1 of the following: Gen Bus 304; OIM 312, 578(T), 632, 633, 654(N)	• Math 309, 310, 340, 521 • either 431 or 443 • 1 of the following: 522, 525 or 632
Chemical Engineering	• CHE 320(T), 326(T), 426(T), 470(T) (A background in Chemical Engineering is needed for this option.)	• Math 319, 321, 322, 521 • either 320 or 340 • 1 of the following: 522, 541, 623 • should consider 431, 443, 632
Chemistry	• either Chem 327 or 329 • both Chem 561 and 562 • Physics 208	• Math 319, 321, 322 • either 320 or 340 • 2 of the following: 521, 541, 623 • should consider 431, 443, 522 and 632

AREA OF APPLICATION	**PART (a): COURSES IN THE AREA OF APPLICATION**	**PART (b): MATH COURSES**
Civil and Environmental Engineering	• Civ. Engr. 310(N), 311(T), 340(N) • 1 of the following: either 440, 445, 447	• Math 319, 321 • either 320 or 340 • either 322 or 443 • 2 of the following: 513, 514, 515, 521, 522, 525 • should consider 431
Computer Sciences (Artificial Intelligence)	• CS 302, 532, 539, 540	• Math 340, 431, 443, 475, 541, 632 • should consider 571 and/or a Stat course
Computer Sciences (Mathematical Programming)	• CS 302, 352, 367, 412 • should consider 635	• either Math 320 or 340 • 443, 475, 521, 525 • 1 of the following: 513, 515, 522 or 623 • should consider 319, 321, 322
Computer Sciences (Numerical Analysis)	• CS 302, 412 • 2 of the following: CS 352, 354, 367; Math 321, 322, 522	• Math 319, 340, 443, 521, 525 • 1 of the following: 513, 514 or 515
Computer Sciences (Systems)	• 4 of the following: CS 302, 352, 354, 367, 536, 537, 538	• Math 340, 443, 475, 525, 541, 571
Computer Sciences (Theory)	• 4 of the following: CS 302, 352, 354, 367, 520, 577	• Math 340, 475, 541, 542, 571 • 1 of the following: either 431 or 521
Cryptography	• CS 302, 367 • either ECE 352 and 641, or CS 537 and 642	• either Math 340 or 341 • 431, 435, 541, 567 • either 542 or 632
Ecology	• 4 of the following: Bot 826* CS 412 Environ. St. 461, 652 Stat course Urban Reg Pl 662 Zoo 504 Zoo/Bot 460 • should consider Zoo 535 or 540	• Math 319, 415, 431, 521, 632 • either 320 or 340 • should consider 443, 513, 514, 525

AREA OF APPLICATION	**PART (a): COURSES IN THE AREA OF APPLICATION**	**PART (b): MATH COURSES**
Economics (Note: The Department of Economics is currently reviewing its Math-related courses.)	• 1 of the following: Econ 101, 102, 111 • both Econ 311 and 312 • 1 of the following: Econ 410, 411, 412, 606, 711* Math 415, 525 or 632 Stat 313, 314 Stat/Math 309, 310	• Math 319, 340, 431, 443, 521 • either 522 or 632 • should consider 415 and 525
Electrical and Computer Engineering	• 4 of the following: ECE 220(T), 230(T), 320(T), 330(T) Physics 241 or 244	• Math 319, 321, 322 • either 320 or 340 • 2 of the following: 521, 522, 525, 541, 561, 623 • should consider 431, 443, 632, 641
Engineering Mechanics and Astronautics	• EMA 201(T) • either 202(T) or 221(T) • either 304(T) or 306(N) • either 542(T) or 545(N)	• Math 319, 321 • either 320 or 340 • either 322 or 443 • 2 of the following: 513, 514, 515, 521, 522, 525 or 623
Finance	• Econ 310, 410 • Finance 300, 320 (Note that this program needs Acct 100.)	• Math 319, 322, 340, 431 • should consider 521, 525, 632
Forestry	• For. 300(T), 410(T), 652(T) • either 625(N) or 635(N) • should consider For. 550(C), Geog/CEE/For. 351, Envirn. St./CEE 352(T), CS 412	• either Math 319 or 525 • 340, 415, 431, 521, 632 • should consider 513, 514 or 515
Genetics	• basic biology course • Genetics/Botany/Zoology 466, Genetics 565(T), 629(T)	• Math 319, 340, 431, 475, 521, 632 • should consider 322
Industrial Engineering	• Ind. Engr. 315(N), 320(T), 321(T) • either IE 525 (also CS, Stat and Math 525) or Math/Ind. Engr. 633	• Math 319, 431, 443 • either 320 or 340 • 2 of the following: 513, 521, 525, 632

AREA OF APPLICATION	**PART (a): COURSES IN THE AREA OF APPLICATION**	**PART (b): MATH COURSES**
Mechanical Engineering	• ME 340(N), 361(T), 363(N), 364(N)	• Math 319, 321 • either 320 or 340 • either 322 or 431 • 2 of the following: 513, 514, 515, 521, 522 or 525
Metallurgical Engineering or Materials Science & Engineering	• MS&E 330(T), 331(T), 351(T), and EMA 214 (T)	• Math 319, 321, 322 • either 320 or 340 • 2 of the following: 513, 514, 515, 521, 522 or 525
Nuclear Engineering and Engineering Physics	• NEEP 305(T), 405(N), 408(N), 411(T)	• Math 319, 321, 322 • either 320 or 340 • 2 of the following: 513, 514, 521, 561, 623 • should consider 431, 443, 632
Physics	• 4 of the following: Physics 241 or 244; 249, 311, 321, 322, 325	• Math 319, 321, 322 • either 320 or 340 • 2 of the following: 521, 522, 541, 561, 623 • should consider 431, 443, 632
Statistics I Note: This program combined with an appropriate Computer Sci. course will satisfy the Stat. major requirements	• Stat 333, 424 • 2 of the following: Stat 349, 351, 411, 421, 611, 641, 756*	• Math 309, 310, 340, 443, 521 • 1 of the following: either 629 or 632
Statistics II	• Stat/Math 309-310, Stat 333, 424	• Math 340, 443, 475, 521 • 2 of the following: 522, 629, 632
Structural Biology	• Biochem 636 • either Chem 327 or 329 • Chem 561, 562, 613 (Note that this option needs Phys 201-202, Phys 207-208 or Phys 247-248. We do not recommend the Phys 201-202 sequence.)	• Math 321, 322, 340, 513, 514 • 1 of the following: 431, 525, 561

AREA OF APPLICATION	**PART (a): COURSES IN THE AREA OF APPLICATION**	**PART (b): MATH COURSES**
Systems Biology	• Biochem 501 • Chem 341 or 343 • 2 of the following: Biochem 601, 612, 620, 621, 624, 630, 702 (Note that this option needs an elementary Chem course, 104 or 109.)	• Math 319, 321, 322, 415, 514, 519 • should consider 331, 431 or 515

*See the L&S Bulletin for rules on enrollment in a graduate course.

REQUIREMENTS FOR HONORS IN THE MATHEMATICS MAJOR

Honors candidates in mathematics must complete the following math honors curriculum with grades of B or better:

521H – 522H; 541H – 542H; two more 5xx or 6xx level courses (551 will usually be one of them)
681H – 682H or the following: six credits in a graduate Math sequence numbered 700 or above.

See Section 7 for information about the scheduled rotation of honors sections, the requirements to enroll in honors sections or for honors credit, and suggested plans for taking the scheduled honors sections. For more information visit the website www.math.wisc.edu/undergrad/honors/honors.html

In order to earn Honors in the Mathematics Major, in addition to completing the basic degree requirements, the student must (1) have a cumulative grade-point average of at least 3.3; (2) be in the Honors Program during the last three semesters before graduation; (3) complete the Mathematics honors curriculum. Transfer students should consult the L&S Honors Program coordinator about the Honors Degree requirements for transfer students. The Undergraduate Catalog contains more detailed information about the Letters and Science Honors Degree requirements.

GENERAL COLLEGE REQUIREMENTS FOR A MAJOR AND THE RESIDENCY REQUIREMENTS

Students must meet the general Letters and Science major requirements. In particular, a math major must have at least a 2.0 grade-point average in all math courses and in all advanced math courses taken in residence; also, at least15 credits in advanced Math courses must be earned in residence. (Other advanced Math credits may be transfer credits.) Note: Math 425 and Math 490 do not count toward the requirements involving advanced Math courses. Students who are earning degrees in the College of Letters and Science but have taken advanced math credits on the Madison campus with a non-L&S classification may request that those credits count toward the 15 required advanced math credits in residence and toward the grade-point average in the advanced math courses. This may be done by the math major advisor recommendation to an L&S dean of student affairs. In addition, a student earning a degree in the College of Letters and Science must complete the last 30 degree credits in residence with an L&S classification. Exceptions to this may be requested through an L&S dean of student affairs. Courses taken on a refresher basis do not count toward any of the above requirements.

The Letters and Science 80 credit rule states that of the minimum 120 credits required for graduation, at least 80 must be earned outside of any one department. A course cross-listed with another may be counted toward those 80 outside credits. Also pre-calculus mathematics courses may be counted toward the 80 credits outside mathematics. The L&S 80-credit rule is not applicable to math majors earning their degrees outside the College of Letters and Science. Students should consult the Undergraduate Catalog for complete details about the L&S requirements.

SECTION 4. ACTIVITIES AND FACILITIES

MATH CLUB

In recent years there has been a very active undergraduate math club that has arranged for talk at a level appropriate for undergraduate math majors. These talks have provided excellent opportunities for undergraduate math majors to meet informally with faculty and graduate students and with each other and to learn about and discuss mathematical topics that are not ordinarily presented in courses. Undergraduates interested in forming a math club may seek support and advice from the Mathematics Department through the Advising Chair.

PUTNAM EXAM PREPARATION

The William Lowell Putnam Mathematical Competition is based on undergraduate mathematics and for the most part tests originality and cleverness rather than sophisticated mathematical knowledge. Cash prizes and a scholarship for graduate studies at Harvard are awarded and a high ranking may be useful for gaining support for graduate studies in mathematics. Students interested in preparation for this exam may participate in the Putnam Club. Although attendance to the club is not required to take the exam, students must have the instructor register them as contestants in order to compete. The instructor selects three contestants to represent the University as a team. The other contestants are entered as individuals. For more information contact: Professor Passman or Professor Borisov.

COMPUTING FACILITIES

The Mathematics Campus Microcomputer Instructional Lab is located in Room 101 Van Vleck (access at the Plaza level). It contains a variety of computers and is available to UW-Madison students, faculty and staff. Required computing for Math courses has first priority.

WEEKLY COLLOQUIA

These talks are usually mathematically technical, but sometimes they are accessible to the advanced undergraduate math major. They are usually held late Friday afternoon, preceded by cookies, coffee and tea in the 9^{th} floor conference room in Van Vleck.

MATH LIBRARY

The Stephen Cole Kleene Mathematics Library is located in Room B224 Van Vleck. It contains an excellent collection of current and back issues of mathematical journals as well as mathematical texts and monographs.

SECTION 5. RELATED PROGRAMS

APPLIED MATHEMATICS, ENGINEERING AND PHYSICS PROGRAM (AMEP)

This four-year program in the physical sciences provides a strong foundation in mathematics and physics with a substantial introduction to engineering science. The program is an excellent choice for a student who has high ability and strong interest in mathematics and physical science and is preparing for further study in a graduate or professional school in applied mathematics and physics is important.

The AMEP requirements include the following:

1) Eight university course credits in any single foreign language acceptable toward fulfilling the Foreign Language Requirement for the BA or BS degree
2) L&S Expository English requirement.
3) At least 20 credits in the College of Letters and Science outside the Division of Physical Science must include at least 12 credits in Humanities and/or Social Studies with at most 10 credits from a single Department.
4) At least one semester course in chemistry. Chemistry 109 recommended.
5) At least 30 credits in mathematics. These must include: Mathematics 221, 222, 234, 321 and 322.
6) At least 28 credits in physics. These must include: Physics 207, 208, 241 and 311; or Physics 247, 248, 249 and 311.
7) At least 21 credits in engineering science forming a progressive and cohesive sequence in one area of some phase of engineering. At least 12 of the 21 credits must be at the intermediate or advanced level.
8) At least 3 approved credits of laboratory experience in the demonstration of physical phenomena and the measurement of physical quantities or equivalent work experience approved by advisors.
9) At least 125 total credits selected from courses offered by College of Letters and Science and/or College of Engineering.

Interested students may obtain more detailed information about this program from the AMEP Program Assistant in Room 218 Van Vleck.

MATH MAJOR IN THE SECONDARY EDUCATION PROGRAM

Positions for teaching mathematics in the public middle, junior high or high schools require teacher certification which may be earned as part of the Secondary Education Program in the School of Education. Students who qualify may transfer to this program when they attain junior standing. Students in this program must satisfy the general secondary education requirements in the School of Education and the secondary education math major requirements stated below.

Admission requirements:

1) At least 2.5 cumulative GPA, on a 4 point scale
2) 28 credits completed in required mathematics courses (can include Statistics 301)
3) Junior standing (54 or more credits completed)
4) For those entering the program in fall 2007 or later: have taken the Pre-Professional Skills Test Praxis I

Graduation GPA requirements: 2.75 cumulative GPA; 2.75 GPA in all math., computer sciences and statistics courses included in the major; 2.75 GPA in professional education course work, excluding the clinical program.

Course requirements (after Math 221, 222 and 234):

Interested students may obtain current information from Education Academic Services, B117, Education Building, or from Eric Knuth, 476C Teacher Education Building, or at www.education.wisc.edu/eas/share_dir/soe_programs/Math.htm

1) Math 340 or 341
2) Math 371
3) Math 461
4) Math 441 or 541
5) Math 475
6) 3 credits of electives from:
   Math 431
   Math 521
   Math 541
   (Note: for students planning to teach calculus, Math 521 is especially recommended; 521-522, 541-542, and 551 are recommended for students planning graduate work in mathematics.)
   Additional credits as needed to reach 34 total.

7) Education courses and student teaching (consult with the program advisors for details).

Advisor: Professor Eric Knuth, 476C Teacher Education Building

Students considering this math program should consult with a program advisor before the junior year. Some of the required education courses are not offered in the summer; and an entire semester must be reserved for student teaching during the senior year. Advice and information about the general requirements of the secondary education program are available at the Office of Student Services of the School of Education, B109 Education Building.

It is possible to complete the requirements for secondary school teacher certification in mathematics after earning an L&S degree with a math major. However, undergraduate SED math majors have priority in the certification program so some years there may be limitations on the number of post-graduate students accepted into the program.

ACTUARIAL MATHEMATICS IN THE SCHOOL OF BUSINESS

Students may major in actuarial mathematics in the School of Business. This would involve transferring to the School of Business in the junior year, satisfying the general requirements of that school and satisfying the Actuarial Science major requirements which are different from the math major requirements in the College of Letters and Science. See the Business School Bulleting for details. As an alternative students interested in actuarial mathematics who wish to earn degrees in the College of Letters and Science have the opportunity to satisfy Option II of the math major requirements with actuarial mathematics as the area of application. In Section 3 of this guidebook thee is a sample program for Option II with actuarial mathematics as the area of application.

Information about Preparation for Actuarial Positions
Students may obtain such information from Professor Edward Frees in the School of Business.

COMPUTER SCIENCES AND STATISTICS MAJORS

There are separate departments in these two disciplines that are closely related to mathematics. Each department offers its own major that is described in the Undergraduate Catalog. Also the Computer Sciences Department has a student handbook with more detailed information. Since students who major in these areas must take considerable mathematics, they should consider a second major in mathematics. In Sect 3 of this guidebook there are several sample programs for Option II of the math major requirements with computer sciences and statistics as the area of application.

SECTION 6. UNDERGRADUATE MATH SCHOLARSHIPS

The University of Wisconsin-Madison offers eight scholarships for undergraduate math majors.

1) R. Creighton Buck Prize: For outstanding creativity in Mathematics; awards vary.

2) Frank D. Cady Scholarship: An annual scholarship for a needy and outstanding student majoring in Mathematics and whose life work will be closely connected with Mathematics. Recipient must be a Junior or Senior.

4) Prof. Linnaeus Wayland Dowling Scholarship: For Math majors; awards vary.

5) Violet Higgitt Scholarship: For Math majors; awards vary.

6) Mark Ingraham Scholarship: An annual scholarship for a Mathematics major above first-year standing. The award may be divided.

7) Irma L. Newman Scholarship: For Math majors; awards vary.

8) A. David. Lawrence Young Memorial Scholarship: For a student showing promise early in his/her career.

These scholarships are awarded in the spring, for the following academic year by the Department of Mathematics Scholarship Committee. The committee solicits nominations from the mathematics faculty, however students who wish to be considered may submit their names to the chairman of the committee.

The Office of Student Financial Aids awards grants and loans based on financial need.

SECTION 7. COURSE ROTATION

CALCULUS AND ADVANCED MATH COURSES NORMALLY OFFERED EVERY SEMESTER:

221, 222, 234, 303, 319, 320, 321, 322, 340, 341, 421, 431, 461, 475, 521, 541, 551, 632, 699

Math 441 offering is coordinated with the School of Education.

SCHEDULE OF ADVANCED UNDERGRADUATE COURSES NOT OFFERED EVERY SEMESTER

The following rotation of courses is scheduled by the Mathematics Department:

Rotation of courses not taught every semester:

Semester I, 2008-2009: 275, 375, 415, 443, 473, 490, 525, 567, 571, 623
Semester II, 2008-2009: 276, 331, 371, 376, 435, 522, 542, 552, 561, 629
Semester I, 2009-2010: 275, 375, 490, 525, 567, 571, 623
Semester II, 2009-2010: 276, 371, 376, 435, 473, 519, 522, 542, 561, 629

OTHER COURSES:

Math/Stat 309 and 310 are usually offered Semester I and Semester II, respectively by the Statistics Department.

Math/Comp Sci 513 and 514 are usually offered Semester I and Semester II, respectively, by the Computer Sciences Department.

Math/Comp Sci 525 is usually offered Semester I and II by the Computer Science Department.

Math 681 and 682 will be available for students working on honors thesis.

Warning: The Math Department may be required to cancel courses in some semesters because of low enrollment or lack of staff. Courses not listed above will be taught infrequently.

HONORS IN CALCULUS AND ADVANCED COURSES.

Math 275, 276 and 375, 376 are the designated honors courses for the calculus sequence. Placement in Math 275-276-375-376 is by invitation. Math 275and Math 375 are offered in the first semester. Math 276 and 376 are offered in the second semester. Interested students should speak to the Departmental Honors Coordinator, the Undergraduate Advisor or the professor scheduled to teach the course.

The Mathematics Department expects to offer honors sections or sections with honors credit available in the advanced undergraduate Math courses according to the following rotation. In the timetable the symbol "!" or "H" will denote a separate honors section and the symbol or"%" will denote that honors credit is available in a regular section.

Semester I	Semester II
341	341
521	522
541	542

In addition, qualified students may enroll for Honors credit in 490, 551, 552, 623, 629 and 632. Other 400, 500 and 600 level courses may occasionally appear in the timetable for honors credit (symbolized by !) or for "honors credit available" (symbolized by %). In addition, any graduate math course may be taken for Honors credit by a qualified undergraduate. The rules of the College of Letters and Science about undergraduates taking graduate courses are in the Undergraduate Catalog.

REQUIREMENTS TO BE ADMITTED IN HONORS SECTIONS OR TO ENROLL FOR HONORS CREDIT

A grade point average of at least 3.5 in all previous math courses number 221 and above is required. A student need not be majoring in math to be in an honors program to enroll in honors sections. Honors sections are designed for students with strong interest in mathematics and/or its applications and who find it stimulating to be in math classes with students with similar interests and high mathematical ability. Note however that students who are not in the Honors program will need authorization from the Mathematics Department to register for Math 275, 276, 375 or 376. Students qualified for these honors courses may request authorization from the Honors Coordinator, the Undergraduate Advisor or Math Placement Advisor.

SUGGESTED SEQUENCES FOR HONORS

The following are suggested plans that enable a student to take the honors sections in 340, 521-522 and 541-542 within three years. Plan A is for those students who begin with 221 or 275, plan B for those who begin with 222 or 276 and plan C for those who begin with 234 or 375.

	Year 1	Year 2	Year 3
Semester l	A. 221 or 275 B. 222 or 276 C. 234 or 375	A. 234 or 375 B. 341, 376 C. 521H, 541H	A. 521H, 541H B. 521H. 541H
Semester ll	A. 222 or 276 B. 234 or 375 C. 341 or 376	A. 341 B. 475 or other choices C. 522H, 542H	A. 522H, 542H B. 522H, 542H

(A student may wish to postpone 521H-522H or 541H-542H for a year or to take 541 before 521.)

SECTION 8. COURSE DESCRIPTIONS (Calculus and Advanced Courses)

ROTATION OF COURSES

See Section 7.

CROSS-LISTED COURSES

The following courses are listed jointly with Mathematics Department and carry the same Math numbers. While they count toward the Mathematics major they are also counted toward the 80 credits outside Mathematics required for an L&S degree.

Business: 632. 633
Computer Sciences: 425, 435, 475, 513, 514, 525
Electrical and Computer Engineering: 435, 641
History of Science: 473
Industrial Engineering: 425, 525, 632, 633
Philosophy: 571
Statistics: 309, 310, 431, 432, 475, 525, 632

CALCULUS AND HONORS IN CALCULUS COURSES

The standard calculus sequence, Math 221-222-234, or the equivalent, forms the basic calculus preparation for the Math major (as well as for many other majors). Math 275-276-375-376, are the designated honors courses for the calculus sequence. Math 275 and 375 are offered each fall semester and Math 276 and Math 376 are offered each spring semester.

MATH 221 CALCULUS AND ANALYTIC GEOMETRY l 5 cr.
MATH 222 CALCULUS AND ANALYTIC GEOMETRY II 5 cr.
MATH 234 CALCULUS-FUNCTIONS OF SEVERAL VARIABLES 3 cr.

This is the basic calculus sequence for students in science, mathematics, computer science and engineering and for other students who want preparation for higher level math courses or some courses in allied fields. Topics in 221: functions, graphs, continuity, differentiation and applications, definite and indefinite integrals and applications, transcendental functions. Topics in 222: methods of integration, first-order differential equations, conic sections, polar coordinates, vector algebra, 3 dimensional analytic geometry, infinite series. Topics in 234: partial differentiation, multiple integrals, vector analysis. Prereq. For Math 221: Math 112 and 113 or Math 114, or satisfactory placement scores. Prereq for Math 222: Math 221. Prereq for Math 234: Math 222. Students may not receive credit for both 211 and 221. Students may not earn full degree credit for both 213 and 222 or for both 213 and 234.

MATH 275 TOPICS IN CALCULUS l 5 cr.
MATH 276 TOPICS IN CALCULUS II 5 cr.

These courses are the designated honors courses for the calculus sequence (Math 221-222). Prereq: Math 275-consent of instructor; Math 276-Prereq: Math 275 or consent of instructor. Note: Students may take 221 and then 276 or 275 and then 222.

MATH 281 TOPICS IN DEDUCTIVE MATHEMATICS 3 cr.

A proof-based introduction to an advanced topic in mathematics presented at the intermediate level. Topic varies. Not open for credit to students who have completed a 300 or higher level math course. Prereq: Math 221 or Math 275, or exemption.

MATH 298 DIRECTED STUDY IN MATHEMATICS 1 to 3 cr.
Prereq: consent of instructor

MATH 303 THEORY OF INTEREST AND LIFE INSURANCE 3 cr. (Same as Act Sci 303)

Application of calculus to compound interest and insurance functions; interest compounded discretely and continuously; the force of interest function; annuities payable discretely and continuously; bonds and yield rates; life tables, life annuities, single and annual premium for insurances and annuities; reserves. Prereq: Math 234 or concurrent registration or consent of instructor.

ADVANCED COURSES

STAT 309 INTRO TO MATHEMATICAL STATISTICS 4 cr. (Same as Stat 309)
STAT 310 INTRO TO MATHEMATICAL STATISTICS 4 cr. (Same as Stat 310)

This sequence introduces the student to the basic concepts and methods of mathematical statistics. It is primarily for majors in Mathematics and statistics. Topics in 309: discrete and continuous probability; combinatorial methods; univariate and multivariate distributions expected values; moments; normal distributions; derived distributions. Topics in 310: unbiased estimation, maximum likelihood estimation, confidence intervals, tests of hypotheses, likelihood ratio tests, general linear model, analysis of variance, data analysis, nonparametric methods. Prereq for 309: Math 234. Prereq for 310: Math 309.

MATH 319 TECHNIQUES IN ORDINARY DEFFERENTIAL EQUATIONS 3 cr.

This course presents techniques for solving and approximating solutions to ordinary differential equations. It is primarily for students in disciplines that emphasize methods of explicit solutions of ordinary differential equations. Math 519 is better suited for math majors and others who need a theoretical background in ordinary differential equations of a more detailed study of systems of differential equations, Laplace transform, boundary value problems, possibly numerical methods and two dimensional autonomous systems. Prereq: Math 222

MATH 320 LINEAR MATHEMATICS 3 cr.

Introduction to linear algebra, including matrices, linear transformations, eignevalues and eigenvectors. Linear systems of differential equations. Numerical aspects of linear problems. Prereq: Math 222. Credit may not be received for both Math 320 and 340.

MATH 321 APPLIED MATHEMATICAL ANALYSIS 3 cr.

The objective of this course is to introduce the students in the physical sciences, engineering and applied mathematics to the basic techniques, concepts and applications of advanced calculus and analytic function theory. Since this course has less depth than Math 521-522 and Math 623, students of physics, engineering and applied math that plan to do advanced graduate work in these areas should take Math 521-522 and 623 also. Topics: vector analysis including algebra of vectors, vector differential and integral calculus, theorems of Green, Gauss and Stokes; functions of several variables including implicit and inverse function theorems, Jacobians, Taylor Series, Lagrange multipliers; functions of a complex variable including analytic functions, Cauchy's theorem and formulas. Taylor and Laurent series, singularities, residues, conformal mapping. Prereq: Math 234.

MATH 322 APPLIED MATHEMATICAL ANALYSIS 3 cr.

This course introduces the student to some techniques of solving partial differential equations. Possible topics: Fourier series' Strum-Liouville theory for second order ordinary differential equations; separation of variables applied to the heart equation, the wave equation and Laplace's equations in various geometries; Fourier transforms; possibly numerical methods, asymptotic methods or method of characteristics. Prereq: Math 319.

MATH 331 INTRODUCTION TO PROBABILITY AND MARKOV CHAIN MODELLING 3 cr.

This course concentrates on discrete models in probability, and beyond a basic introduction to the subject, it presents material on Markov chains. It is similar to Math 431, but our focus on discrete models allows us to go a bit further into the subject. Designed for Computer Science majors. Prereq: Math 234 or Math 222 and Math 240.

MATH 340 ELEMENTARY MATRIX AND LINEAR ALGEBRA 3 cr.

This course introduces the student to matrix and linear algebra that are used in many advanced math courses and courses in other departments. Math 340 also serves as a bridge between the problem solving calculus courses and the more abstract advanced math courses; it is a prerequisite for 521, 541 and may other advanced courses. Topics: Matrix algebra, systems of linear equations, determinants, vector spaces, linear independence, bases, dimension, linear transformations, eigenvalues, eigenvectors, inner product, orthogonality, diagonalization. Prereq: Math 222 and Math 240 or Math 234. Students may not receive credit for both 320 and 340.

MATH 341 LINEAR ALGEBRA 3 cr.

This course covers the topics in regular linear algebra course but emphasizes the understanding of concepts. It teaches to write and understand proofs in mathematics in general and in linear algebra in particular. A student cannot receive credit for both Math 340 and Math 341 or for both Math 375 and Math 341. Prereq: Math 234 or consent of instructor.

MATH 371 BASIC CONCEPTS OF MATHEMATICS 3 cr.

This course is designed to help students make the transition to the 500 and 600 level courses in which there is more emphasis on proofs. It will help students understand proofs and devise concise proofs as well as introduce them to some basic mathematical knowledge. Topics: informal treatment of prepositional and first-order logic; proof techniques; naïve set theory; relations and functions; Peano axioms; construction of the reql numbers; countable and uncountable sets; Axiom of Choice and Zorn's Lemma. Prereq: Math 340 or concurrent registration in 340.

MATH 375 TOPICS IN MULTI-VARIABLE CALCULUS AND LINEAR ALGEGRA 5 cr.

This course is the third semester in the honors calculus sequence. Topics include: vector spaces and linear transformations, differential calculus of scalar and vector fields, determinants, eigenvalues and eigenvectors, multiple integrals, line integrals and surface integrals. Prereq: Math 276 or consent of instructor.

MATH 376 TOPICS IN MULTI-VARIABLE CALCULUS AND DIFFERENTIAL EQUATIONS 5cr

This course is the fourth semester of the honors calculus sequence. It develops topics in multi-variable calculus not covered in the third semester, Math 375 and presents an introduction to differential equations.

MATH 415 APPLIED DYNAMICAL SYSTEMS, CHAOS AND MODELING 3 cr.

An introduction to non-linear dynamical systems including stability, bifurcations and chaos. The course will give underlying mathematical ideas, but emphasize applications from many scientific fields. Prereq: Math 319 or 320 or consent of instructor.

MATH 421 THE THEORY OF SINGLE VARIABLE CALCULUS 3 cr.

This course covers material in first and second semester calculus, but it is intended to teach math majors to write and understand proofs in mathematics in general and in calculus in particular. A student cannot receive credit for Math 421 if they have taken Math 275-Math 276. Prereq: Math 234 or consent of instructor.

MATH 425 INTRODUCTION TO COMBINATORIAL OPTIMIZATIONS 3 cr. (Same as Computer Sci. 425 and Industrial Eng. 425)

Exact and heuristic methods for key combinatorial optimization problems such as: shortest path, maximum flow problems and the traveling salesman problem. Techniques include problem-specific methods and general approaches such as: branch-and-bound, genetic algorithms, simulated annealing, and neural networks. Prereq: Math 221 or CS302 or consent of instructor. **NOTE:** This is an intermediate level course and does not count toward the 15 upper level residence Math credits required for the Math major nor toward the 2.0 GPA required in the upper level courses in the major.

MATH 431 INTRODUCTION TO THE THEORY OF PROBABILITY 3 cr. (Same as Stat 431)

This is an introduction to the basic ideas of probability for students with a good calculus background. It is of particular interest to students in mathematics, statistics, physical and biological sciences and engineering and also to students in some of the social sciences. Topics: sample spaces , probability measures, combinatorial analysis, conditional probability, independence, random variables, distributions, expectation, laws of large numbers, central limit theorem. Prereq: Math 234.

MATH 435 INTRODUCTION TO CRYPTOGRAPHY 3cr. (Same as Comp Sci 435 and ECE 435)

Survey of methods for transmitting digital information over insecure channels. Classical ciphers and their cryptoanalysis, public-key systems, protocols for security and authentication.

MATH 441 INTRODUCTION TO MODERN ALGEBRA 3 cr.

This course will serve as a transition from Math 340 to Math 541 for those who might otherwise find Math 541 particularly difficult. It may fulfill the present "Math 541" requirement for Secondary Education mathematics majors with prior approval of the Education Math advisor. Topics: thorough discussion of the integers with emphasis on properties relevant to more general groups and rings, permutation groups (symmetry groups) and polynomical rings leading to the notions of abstract groups and rings, congruences and computations including finite fields and their application. The emphasis of this course is on concepts and concrete (but general) examples and computations, rather than complicated proofs. Prereq: Math 340 **NOTE**: Students who have passed Math 541 are not permitted to take Math 441 for credit.

MATH 443 APPLIED LINEAR ALGEBRA 3 cr.

This is a second course in linear algebra for the applied science students. The emphasis is more on the facts of linear algebra than on proofs. Math 542 presents a more abstract study of linear algebra more suitable for students preparing for graduate study in mathematics. Topics: matrices; determinants; linear equations; eigenvalues and eigenvectors; similarity; inner products; unitary; Hermitian and normal matrices; variational principles; perturbation theory; quadratic forms; canonical forms. Prereq: Math 320 or 340 or consent of instructor.

MATH 461 COLLEGE GEOMETRY 3 cr.

This is a geometry course for students with some mathematical sophistication (calculus). It is of particular interest to, but not exclusively for, prospective secondary school teachers. Topics in Eudlidean and/or non-Euclidean geometry are studied from a broad point of view. The course may include the foundations of geometry as well as advanced topics. Prereq: Math 234.

MATH 473 HISTORY OF MATHEMATICS 3 cr. (Same as Stat 475 and Computer Sci. 475)

This course will trace the development of some of the central ideas of mathematics from antiquity to the present time. There will be problem sets and short essays. This course has been designated a "writing-intensive course". Prereq: An introductory course in analytic geometry and calculus.

MATH 475 INTRODUCTION TO COMBINATORICS 3 cr. (Same as Stat 475 and Computer Sci 475)

This is an introduction to the ideas and techniques of combinatorics, many of which have applications to the physical, biological and social sciences, as well as in mathematics and computer science. The emphasis is on problem solving and constructive methods. Topics: pigeonhole principle, permutations and combinations, binomial coefficients, inclusion-exclusion principle, recurrence relations, systems of distinct representatives, combinatorial designs, graph theory, optimization problems. Prereq: Math 320 or 340 or consent of instructor.

MATH 490 UNDERGRADUATE SEMINAR 1-3 cr.

This course is not offered on a regular basis. This topics course is used to present undergraduate work and/or courses on special topics. Prereq: Math 234 and consent of instructor.

MATH 491 TOPICS IN UNDERGRADUATE MATHEMATICS 3 cr.

This course is not offered on a regular basis. This topics course will be used for experimenting with new courses and for presenting special topics. Prereq: Math 234 and consent of instructor.

MATH 513 NUMERICAL LINEAR ALGEBRA 3cr. (Same as Computer Sci 513)

Topics: Direct and iterative solution of linear and non-linear systems and of eigen problems. LU and symmetric LU factorization. Complexity, stability, and conditioning. Non-linear systems, Iterative methods for linear systems, OR-factorization and least squares. Eigen problems: local and global methods. Prereq: Math 341 or equivalent and CS302 or equivalent.

MATH 514 NUMERICAL ANALYSIS 3 cr. (Same as Computer Sci 514)

Topics: Polynomial forms, divided differences. Ploynomial interpolation, Polynomial approximation: uniform approximation, and Chebyshev polynomials, least-squares approximation and orthogonal polynomials. Numerical differentiation and integration. Splines, B-splines and spline approximation.

Numerical methods for solving initial and boundary value problems for ordinary differential equations. Prereq: Math 340 or equivalent, CS 302 or equivalent.

MATH 519 ORDINARY DIFFERENTIAL EQUATIONS

Math 519 is a rigorous self-contained introduction to ordinary differential equations intended for undergraduate math majors and advanced or graduate students from economics, engineering and physics. Topics will include theory of linear systems based on linear algebra, proof of basic existence theorems, stability theory, bifurcations and applications to mechanical and biological systems. Prereq: Math 340, 319 and 521.

MATH 521 ADVANCED CALCULUS l 3 cr.
MATH 522 ADVANCED CALCULUS II 3 cr.

This sequence introduces students to the terminology, fundamental concepts and basic elementary theorems of analysis with emphasis on functions of several variables. The objective is to convey an understanding of the structure of analysis in itself as well as its role as a tool for other disciplines. This sequence is essential for students preparing for graduate studies in mathematics; also it should be taken by students of physics and engineering who intend to do graduate work in their areas. Topics in 521: Topological notions, mappings, continuity, differentiation, integration, series and possibly Fourier series. Topics in 522: Differentials of functions and transformations, inverse transformations, implicit function theorem, transformations of multiple integrals, curves and surfaces, numerical methods, line and surface integrals, the theorems of Gauss, Green and Stokes and applications. Prereq for 521: Math 340 or concurrent enrollment. Prereq for 522: Math 521.

MATH 525 LINEAR PROGRAMMING METHODS 3 cr. (Same as Computer Sci 525, Industrial Eng. 525, Stat 525)

Topics: Real linear algebra over polyhedral cones; theorems of the alternative for matrices; formulations of linear programming problems; duality theory an solvability; the simplex method and related methods for efficient computer solution; perturbation and sensitivity analysis; applications and extensions such as game theory, linear economic models, and quadratic programming. Prereq: Math 320, 340 or 443 or consent of instructor.

MATH 541 MODERN ALGEBRA l 3 cr.

This is the first semester of an introduction to basic abstract algebra. It is essential for students preparing for graduate studies in mathematics or in some related fields. Topics: group theory: subgroups, homomorphisms, isomorphisms, normal subgroups, permutation groups, class equation, Sylow theorem, finite abelian groups; ring theory: homomorphisms, isomorphism, ideals, integral domains, polynomial rings. Prereq: Math 320 or 340 or consent of instructor.

MATH 542 MODERN ALGEBRA II 3 cr.

This is a continuation of Math 541 with emphasis on linear algebra and field theory. It is a basic course for the student preparing for graduate work in mathematics. Topics: vector spaces: subspaces,

homomorphisms, quotient spaces, bases, dual spaces, inner product spaces, modules; field theory: extension fields, transcendence of "e", roots of polynomials, construction with straightedge and compass; linear transformations: algebra of linear transformations, eigenvalues, eigenvectors, matrices, canonical forms, determinants. Prereq: 541.

MATH 551 ELEMENTARY TOPOLOGY 3 cr.

This is an introduction to the basic ideas and methods of point set topology. It is a good background for analysis courses and graduate topology courses. Topics: basic intuitive set theory, topological spaces, separation axioms, compactness, connectedness, metric spaces, special topics. Prereq: Math 234 (normally it is advisable to have at least one previous "abstract" courses such as Math 521 or 541 before taking Math 551).

MATH 561 DIFFERENTIAL GEOMETRY 3 cr.

Curves and surfaces in three and higher dimensional spaces are studied using calculus. The course is useful as preparation for the study of differentiable manifolds and for some aspects of applied mathematics and physics. Topics: curves, arc length, Serret-Frenet equations, two-dimensional surfaces, first and second fundamental forms, geodesics, Gauss-Bonnet theorem. Prereq: Math 320 or 340 and 521 (Math 321 or 522 also recommended).

MATH 567 ELEMENTARY NUMBER THEORY 3 cr.

This is an introduction to number theory. Topics: divisibility, primes, congruences, quadratic reciprocity, number-theoretic functions, Diophantine equations, Farey fractions, continued fractions, elementary distribution of prime numbers. Prereq: Math 340 or concurrent enrollment.

MATH 571 MATHEMATICAL LOGIC 3 cr. (Same as Philos. 571)

This course presents basic logical concepts underlying mathematics and computer science. Topics include prepositional logic, models of predicate logic, formal proofs in predicate logic, completeness and compactness theorems, computability, undecidability theorems. Software developed for the course will be used extensively. Prereq: Math 234 or equivalent.

MATH 623 COMPLEX ANALYSIS 3 cr.

This is an introduction to the theory of analytic functions of a complex variable. Attention is given to the techniques of complex analysis as well as the theory. It is particularly suitable for students in the physical sciences and engineering as well as math majors. Topics: complex numbers, elementary functions, analyticity, complex integration, Cauchy's theorem and formula, power series, residues, conformal mapping, harmonic functions. Prereq: math 321 or 521.

MATH 629 INTRODUCTION TO MEASURE AND INTEGRATION 3 cr.

This is an introduction to measure and integration theory. It is particularly suitable for further studies in analysis, probability or statistics. Topics: Lebesgue integration, convergence theorems, general measure theory, differentiation, applications to probability. Prereq: Math 521.

MATH 632 INTRODUCTION TO STOCHASTIC PROCESSES 3 cr. (Same as Stat., Industrial Eng., Bus. 632)

This is a continuation of the introduction of probability begun in Math 431 with particular emphasis on stochastic processes. Topics: Markov chains (discrete time); stationary distributions of a Markov chain; Markov pure jump processes (continuous time); topics chosen from random walks, renewal theory, semi-Markov processes, Brownian motion and optimal stopping. Prereq: math 431, or Stat 309-310 or Stat 311-312, or Stat 313-314.

MATH 633 QUEUEING THEORY AND STOCHASTIC MODELING 3 cr. (Same as Industrial Eng. And Bus. 633)

This is oriented towards study of the stochastic models that arise in operations research and management science. Emphasis is on queuing models and their related stochastic properties. Topics: reliability theory; coherent systems and reliability bounds; Markovian queues and Jackson networks; steady-state behaviour of general service time queues; priority queues; approximation methods and algorithms for complex queues; simulation; dynamic programming, applications to inventory and queuing. Prereq: Math 632 or consent of instructor.

MATH 635 INTRODUCTION TO BROWNIAN MOTION AND STOCHASTIC CALCULUS

Math 635 is an introduction to Brownian motion, stochastic calculus and some applications. The course does not require knowledge of measure theory. However, it is highly advisable to have some familiarity with elementary probability and stochastic processes. Topics will include sample path properties of Brownian motion, Ito stochastic integrals, Ito's formula, Stochastic differential equations and properties of their solutions and applications. Prereq: Math 521 and 632.

MATH 641 INTRODUCTION TO ERROR-CORRECTING CODES 3 cr. (Same as ECE 641)

This is a first course in coding theory. It is of interest to mathematicians, computer scientists, statisticians and electrical engineers. Topics: linear codes, decoding and encoding; Hamming codes, Shannon's theorem on existence of good codes; binary Golay code; finite fields and BCH codes; dual codes and the weight distribution; cyclic codes: generator polynomial and check polynomial; Reed-Soloman codes and burst errors; Euclidean algorithm for decoding BCH codes; Reed-Muller codes. Prereq: Math 320 or 340, and 541 or consent of instructor.

MATH 681-682 SENIOR HONORS THESIS variable credit

This course is used for work on the honors thesis under the supervision of a faculty member. Prereq: senior standing and enrollment in the math honors program.

Math 691-692 UNDERGRADUATE THESIS variable credit

This course is used for work on the honors thesis under the supervision of a faculty member. Prereq: Consent of instructor.

MATH 699 DIRECTED STUDY variable credit

This course may be used for individual work, supervised by a faculty member, in an advanced mathematical topic not ordinarily included in math courses. Prereq: previous or concurrent enrollment in an intermediate level math course and consent of the instructor.

SECTION 9. MATHEMATICS FACULTY 2009 - 2010

(**Name**; University and year of Ph.D.; Specialization)

Ahern, Patrick; University of Minnesota, 1963; Complex Analysis (Emeritus)

Anderson, David; Duke University, 2005; Probability

Angenent, Sigurd; University of Leiden, 1986; Partial Differential Equations

Askey, Richard; Princeton University, 1961; Special Functions, Orthogonal Polynomials (Emeritus)

Assadi, Amir; Princeton University, 1978; Topological and Geometric Symmetry, Computational Vision

Bach, Eric; University of California-Berkeley, 1984; Theoretical Computer Science (Affiliate)

Bauman, Steven; University of Illinois, 1962; Abstract Finite Groups (Emeritus)

Beck, Anatole; Yale University, 1956; Analysis, Topological Dynamics

Bertrand, Florian; University of Aix-Marseille I, 2007 Analysis

Benkart, Georgia; Yale University, 1974; Non-associative Rings and Algebras; Associative Rings and Algebras (Emeritus)

Bolotin, Sergey; Moscow State University, 1982; Dynamical Systems

Boston, Nigel; Harvard University, 1987; Number Theory, Group Theory and Applications of Algebra to Engineering

Brualdi, Richard; Syracuse University, 1964; Combinatorics, Graph Theory, Matrix Theory, Coding Theory (Emeritus)

Bucklew, James; Purdue University, 1979; Communication and Information Theory (Affiliate)

Cai, Jin-Yi; Cornell University, 1986; Computational Complexity Theory (Affiliate)

Caldararu, Andrei; Cornell University, 2000; Algebraic Geometry

Chen, Xiuxiong; University of Pennsylvania, 1994; Differential Geometry, Global Analysis

Chover, Joshua; University of Michigan, 1952; Probability Theory and Neutral Network Modeling (Emeritus)

Conner, Howard; M.I.T., 1961; Matrix Theory and Computer Graphics (Emeritus)

Craciun, Gheorghe; Ohio State University, 2002; Applied Mathematics

Crowe, Donald; University of Michigan, 1959; Geometry (Emeritus)

deBoor, Carl; University of Michigan, 1966; Approximations and Expansions, Numerical Analysis (Emeritus)

Denissov, Serguei; Moscow State University, 1999; Mathematical Physics and Analysis

Dickey, R. Wayne; N.Y.U., 1965; Applied Mathematics

Ellenberg, Jordan; Harvard, 1998; Number Theory and Arithmetic Geometry

Fadell, Edward; Ohio State University, 1952; Algebraic Topology, Fixed Point Theory (Emeritus)

Feldman, Mikhail; University of California-Berkeley, 1994; Partial Differential Equations

Fish, Alexander; The Hebrew University of Jerusalem, 2006; Combinatorics, Ergonic Theory, Number Theory, Harmonic Analysis

Folsom, Amanda; UCLA, 2006, Number Theory

Gong, Xianghong; University of Chicago, 1994; Complex Variables

Griffeath, David; Cornell University, 1976; Probability, Stochastic Processes and Complex Systems

Gunji, Hiroshi; Johns Hopkins University, 1962; Algebraic Geometry and Number Theory (Emeritus)

Hellerstein, Simon; Syracuse University, 1961; Complex Analysis (Emeritus)

Husseini, Sufian; Princeton University, 1960; Algebraic Topology, Manifolds and Cell Complexes (Emeritus)

Ionescu, Alexandru; Princeton University, 1999; Harmonic Analysis

Isaacs, I. Martin; Harvard University, 1964; Group Theory, Algebra

Jin, Shi; University of Arizona, 1991; Applied Mathematics

Johnson, Arnold; University of Notre Dame, 1965; Classical Groups (Emeritus)

Johnson, Millard; M.I.T., 1957; Applied Mathematics (Emeritus)

Kalafat, Mustafa; SUNY at Stoneybrook, 2007; Geometry

Keisler, H. Jerome; University of California-Berkeley, 1961; Logic and Foundations, Nonstandard Analysis (Emeritus)

Kiselev, Alexander; California Institute of Technology, 1996; Analysis and Applied Mathematics

Klemm, Albrecht; University of Heidelberg, Germany, 1990; Mathematical Physics

Kuelbs, James; University of Minnesota, 1965; Probability Theory and Stochastic Processes (Emeritus)

Kunen, Kenneth; Stanford University, 1968; Logic, Set Theory, General Topology (Emeritus)

Kurtz, Thomas; Stanford University, 1967; Probability Theory and Stochastic Processes (Emeritus)

Lempp, Steffen; University of Chicago, 1986; Logic, Computability Theory

Levy, Lawrence; University of Illinois, 1961; Associative Rings and Modules (Emeritus)

Lumelsky, Vladimir; Institute of Control Sciences of the USSR National Academy of Sciences, Moscow, 1970; Mechanical Engineering (Affiliate)

Masri, Riad; University of Texas, Austin, 2005, Algebra

Marí Beffa, Gloria; University of Minnesota-Minneapolis, 1991; Differential Geometry/Math Physics

Maxim, Laurentiu; University of Pennsylvania; Topology

McMillan, D. Russell, Jr.; University of Wisconsin-Madison, 1960; Geometric Topology (Emeritus)

Mehrotra, Sukhendu; University of Pennsylvania, 2005; Algebraic Geometry

Miles, Philip; Yale University, 1960; Curriculum Development (Emeritus)

Milewski, Paul; M.I.T., 1993; Applied Mathematics, Fluid Mechanics, Waves, Applied Mathematics

Millar, Terrence; Cornell University, 1976; Logic, Model Theory

Miller, Arnold; University of California-Berkeley, 1978; Logic

Miller, Joseph; Cornell University, 2002, Logic

Mitchell, Julie; University of California-Berkeley, 1998; Mathematical and Computational Methods for Biology and Chemistry

Nagel, Alexander; Columbia University, 1970; Several Complex Variables, Harmonic Analysis

Nazarov, Fedor; St Petersburg State University, Russia, 1993; Analysis

Ney, Peter; Columbia University, 1960; Probability and Stochastic Processes (Emeritus)
Ng, Selwyn; Victoria University of Wellington, 2009; Logic

Oh, Yong-Geun; University of California-Berkeley, 1988; Symplectic Geometry and Topology

Ono, Ken; UCLA, 1993; Number Theory, Elliptic Curves and Modular Forms

Orlik, Peter; University of Michigan, 1966; Manifolds and Cell Complexes; Algebraic Geometry; Singularities (Emeritus)

Osborn, J. Marshall; University of Chicago, 1957; Lie Algebras, Non-associative Rings and Algebras (Emeritus)

Parter, Seymour; NYU, 1957; Numerical Analysis, Ordinary Differential Equations, Differential Equations (Emeritus)

Passman, Donald.; Harvard University, 1964; Associative Rings and Algebras, Group Theory

Paul, Sean; Princeton, 2000; Complex Algebraic Geometry

Rabinowitz, Paul; N.Y.U., 1966; Partial Differential Equations, Nonlinear Analysis

Rall, Louis; Oregon State University 1956; Numerical Analysis, Scientific Computation (Emeritus)

Ram, Arun; University of California-San Diego, 1991; Representation Theory and Algebraic Combinatorics

Robbin, Joel; Princeton University, 1965; Global Analysis, Differential Equations

Ron, Amos; Tel-Aviv University, 1987; Approximation (Affiliate)

Rosay, Jean-Pierre; University of Grenoble, 1970; Several Complex Variables, Harmonic Anaylsis, Partial Differential Equations

Rossmanith, James; University of Washington, 2002; Numerical analysis and Scientific Computing

Rudin, Mary Ellen; University of Texas, 1949; Set Theoretic Topology (Emeritus)

Rudin, Walter; Duke University, 1949; Complex and Harmonic Analysis (Emeritus)

Schneider, Hans; University of Edinburgh, 1952; Linear Algebra, Matrix Theory (Emeritus)

Seeger, Andreas; Technical University, Darmstadt (Germany), 1985; Analysis

Seppalainen, Timo; University of Minnesota, 1991; Probability Theory and Stochastic Processes

Shea, Daniel; Syracuse University, 1965; Complex Analysis, Integral Equations (Emeritus)

Shen, Mei-Chang; Brown University, 1963; Applied Mathematics (Emeritus)

Slemrod, Marshall; Brown University, 1969; Applied Mathematics (Emeritus)

Smart, Rod; Michigan State University, 1961; Number Theory, Modular Forms (Emeritus)

Smith, Leslie; M.I.T., 1988; Applied Mathematics

Solomon, Louis; Harvard University, 1958; Group Theory, Combinatorics (Emeritus)

Stikwerda, John; Stanford University, 1976; Numerical Analysis, Partial Differential Equations (Affiliate)

Street, Brian; Princeton University, 2007; Analysis

Terwilliger, Paul; University of Illinois-Champaign-Urbana, 1982; Combinatorics, Graph Theory

Thiffeault, Jean-Luc; University of Texas – Austin, 1998; Applied Math

Tseng, Hsian-Hua; University of California-Berkeley, 2005; Geometry

Tudorascu, Adrian; Carnegie Mellon, 2005, Analysis

Turner, Robert E. L.; N.Y.U., 1963; Nonlinear Functional Analysis, Differential Equation, Hydrodynamics, Neuroscience (Emeritus)

Uhlenbrock, Dietrich; N.Y.U., 1963; Quantum Mechanics, Statistical Mechanics, Mathematical Physics (Emeritus)

Valco, Benedek; Technical University, Budapest, 2004. Probability

Viaclovsky, Jeff; Princeton, 1999; Geometric Anaylsis

Voichick, Michael; Brown University, 1962; Complex Analysis (Emeritus)

Wainger, Stephen; University of Chicago, 1961; Harmonic Analysis

Waleffe, Fabian; M.I.T., 1989; Applied Mathematics

Wei, Dongming; University of Maryland, College Park, 2007, Analysis

Wilson, Robert; University of Wisconsin-Madison, 1969; Combinatorics and Math Education (Emeritus)

Yang, Tonghai; University of Maryland, 1995; Number Theory