PROPOSAL FOR A REVISION OF THE UNDERGRADUATE DEGREE REQUIREMENTS IN THE DEPARTMENT OF MATHEMATICS

I. EXECUTIVE SUMMARY

The Department of Mathematics proposes to revise the mathematics undergraduate curriculum in order to:

1. Capitalize on the newly developing strengths within the university, such as the Mathematical Biosciences Institute.

2. Create more choices of degree track for undergraduate majors, directed towards the diversity of new and expanding fields such as mathematical finance, mathematical biosciences, coding theory and cryptography, etc.

3. Formalize some changes that have been occurring in an ad hoc way for several years.

A reduced set of Core Requirements for all mathematics majors has been established. This set of Core Requirements will typically be completed by students during their first two years of study, although honors students or students with advanced placement credit can complete the Core in four academic quarters.

Beyond this set, students have the opportunity to choose from among six degree tracks:

a. Traditional Track
b. Education Track
c. Applied Track
d. Applied Discrete Track
e. Financial Track
f. Bio-Math Track

The Traditional Track is unchanged from the current traditional major program. Likewise the Education Track simply clarifies the currently recommended program of study for students whose goal is a career is secondary education. It affords a bit of additional choice between differential equations and discrete modeling, while remaining consistent with Ohio State standards for licensure in secondary mathematics education.

The Applied Track is substantially revised and clarified. The set of required courses is changed only slightly by the addition of Math 345 and the removal of Math 513. The principal change occurs in the elective courses in which emphasis is placed on the interdisciplinary nature of this track. Students are now required to take a 9 credit sequence of courses in a physical science or engineering discipline, closely correlated with their advanced mathematics studies. The Applied Track requires three more credit hours of course work than did the earlier Applied-Math Option, but it more than compensates for that by giving focus and guidance, directing students towards important fields of application for their mathematical skill set.

The remaining three tracks (Applied Discrete, Financial, and Bio-Math) are entirely new and reflect the rapid growth of employment opportunities for mathematicians in the areas of computers and national security, of finance and risk management, and of mathematical bio-sciences. The Applied Discrete Track builds on the traditional strengths of our faculty in logic and combinatorial mathematics, along with close working relationships with the Department of Computer Science and Engineering. The Financial Track builds on the great success of our undergraduate Actuarial Science degree program, housed in the Department of

Mathematics, and supplements it with additional material preparing students for master's level study in financial mathematics. Finally, the Bio-Math Track exploits the presence of the National Science Foundation-funded Mathematical Bio-Sciences Institute at the Ohio State University to provide a unique opportunity for students to study and do research in the growing fields of mathematical and statistical bio-sciences. We already have students expressing interest in pursuing this degree track.

Revision of the Curriculum for the Bachelor of Science and Bachelor of Arts Degree Programs in Mathematics

I. GENERAL INFORMATION

1. This is a revision of the current mathematics major. It is designed to offer additional tracks towards a degree in mathematics. This is consistent with the latest trends at successful undergraduate programs. A highly regarded and very successful program is the one at UCLA. Their program features a very similar set of tracks to the ones which we are proposing.

2. The degree titles are Bachelor of Science in Mathematics and Bachelor of Arts in Mathematics. The two degrees differ only in their GEC requirements, which are not affected by this proposal. These changes do not constitute a new degree or major, only a change of requirements within the major.

3. Autumn Quarter 2009 is the proposed implementation date.

4. The major is administered by the Department of Mathematics, in the College of Mathematics and Physical Sciences.

II. RATIONALE

5. Rationale for the proposed revisions

Under the current requirements, there are two possible tracks to an undergraduate major in mathematics: a traditional track and an applied track. Even this is not clearly formulated in the current version, and so at the very least a clarification would be in order. There is also an actuarial science undergraduate major, based in the Department of Mathematics, but not a part of the mathematics major.

More important is the fact that, although the "traditional" track is basically sound as a preparation for students wishing to seek secondary education certification or wishing to continue to graduate school in mathematics, the current "applied option" provides little guidance to students wishing to pursue one of the many possible careers open to people with a good undergraduate mathematics education.

Indeed, with each new year, the variety of careers requiring a deep understanding of mathematics increases. The Department of Mathematics wishes to structure a program which accommodates as much flexibility as possible for students wishing to pursue an undergraduate degree in mathematics as a foundation for their future careers.

Over the past decades, the strength of the Department of Mathematics in a variety of aspects of applied mathematics has grown considerably, most notably, but not exclusively, through the creation of the NSF-funded Math Biology Institute. This gives our Department the breadth and strength of faculty to provide strong training for our students in a variety of mathematical tracks. The purpose of this proposal is to offer students these educational choices and to provide templates for them of good programs of study to achieve their diverse career goals.

Thus, instead of two tracks, we now propose six degree tracks, simultaneously providing more guidance for students towards varied career goals and more flexibility in designing programs that fit their needs.

The BS (and BA) in Mathematics will consist of two phases of study: Core Curriculum for Freshmen and Sophomores; and Career Tracks for Juniors and Seniors.

Core Curriculum – course work for the Freshman and Sophomore years:

These are the 20 – 29 credit hours of foundational courses required of all students earning a degree in mathematics. The principal portion is the Calculus Sequence comprising 20 credit hours, taken in four sequential 5-credit courses. Students with some exposure to high school calculus are encouraged to take the accelerated or honors sequences, which complete this material in three 5-credit courses. The core is completed with a fundamental course in linear algebra and a course in foundations of higher mathematics, which provides the conceptual basis for all advanced study in mathematics. Students who follow the highest honors track (190H-191H-264H) receive this conceptual training already in the 190H-191H sequence, and are therefore exempted from taking the Math 345 foundations course. Students in the highest honors track can complete the core curriculum in four quarters with four 5-credit courses: 190H-191H-264H-520H.

Advanced Career Tracks

These are the additional 37 – 47 credit hours of advanced course work, providing students the choice of six tracks customized to different career paths in mathematics and allied disciplines.

The Traditional Track is almost identical to the old Traditional Degree. The set of elective options is slightly enlarged and updated. It is the standard training for students wishing to pursue graduate study in mathematics. It has been very successful for this purpose, particularly in the honors version.

The new Education Track corresponds closely to the degree program currently recommended to all students wishing to seek secondary education licensure in mathematics. It has served this purpose very well in the past. The set of required courses is identical with that of both the old and new Traditional Tracks, except that Math 578 (Discrete Mathematics Modeling) is an alternative choice to Differential Equations. The set of elective courses is shorter than that for the Traditional Track in order to provide guidance to students concerning which electives are best suited to prepare them for a career in secondary education. Indeed, the elective courses Math 504, 507, and 578, and Statistics 420 and 421 are required for admission to the O.S.U. M.Ed. program. A student choosing to use Math 578 as a required course, could then elect Math 504 and 507, and Stat 420 and 421, to complete the 20 required elective hours in this degree track.

The new Applied Track is similar to the existing Applied Option as regards required courses. [Math 345 is now required, and Vector Analysis is no longer required.] The number of required elective hours is increased from 15 to 18, but more important, the electives bring into clear focus some of the most important sequences in applied disciplines, such as chemistry, physics, mechanical engineering, electrical and computer engineering, which mesh well with the applied expertise of members of the Mathematics Department faculty, and complement the courses offered by the department.

The new Financial Math Track has been introduced to provide an alternative to the Actuarial Science major for the rapidly growing number of students seeking majors in the burgeoning financial mathematics field. Increasingly, employers seek students with greater breadth of knowledge in mathematics than that offered by the Actuarial Science major. The use of stochastic differential equations is becoming widespread in risk

analysis and derivative pricing. Thus we have included a requirement of a differential equations course and a numerical analysis course which, together with probability and statistics, form the underpinnings for the study of stochastic differential equations. The new course, Introduction to Mathematical Finance, will give students an introduction to these methods. The Department of Mathematics is developing a targeted M.S. degree in financial math, and this undergraduate Financial Math Track will be the perfect preparation for this master's program.

The new Bio-Math Track reflects the rapidly growing interface between biology and mathematics. The new faculty and resources associated with the N.S.F.-funded Mathematical Biosciences Institute and the Targeted Investment for Excellence in this field will give us the ability to provide superb training and undergraduate research opportunities for students in this newly emerging field. This undergraduate track will provide excellent preparation for students planning for graduate study in bio-mathematics and will also be an atractive option for pre-Med students wanting a distinctive major to set themselves apart among the applicants to medical school. The Department of Mathematics is developing a targeted M.S. degree in bio-mathematics, and this undergraduate track will provide excellent preparation for this master's program.

The new Applied-Discrete Track is designed for students interested in careers in the areas of software design, cryptography, cryptology, optimization, and other related fields, for which a combination of expertise in discrete mathematics (graph theory, coding theory, etc.) and computer programming is the ideal preparation. The track combines a solid major in discrete mathematics with a minor in computer and information sciences.

6. **Unique characteristics and resources that make it appropriate for Ohio State to offer the program.**

Ohio State has a distinguished Department of Mathematics and has been offering a very successful undergraduate program in mathematics for many decades. In particular, our Department has very high national ranking in combinatorial mathematics, which will support the Applied Discrete track in conjunction with our CS&E Department. The Financial Math Track will build on the established and growing success of our Actuarial Science degree, and the Bio-Math Track will benefit immensely from the presence at Ohio State of the National Science Foundation-funded Mathematical Biosciences Institute.

7. **Benefits for students, the institution, the region and the state.**

The State has set the highest priority on the training of more students in STEM disciplines. The introduction of new and attractive tracks in the mathematical sciences, with clearly articulated career goals, can only help in the recruitment and retention of more and better students majoring in mathematics at Ohio State, and contributing after graduation to the highly qualified technologically sophisticated workforce of the State of Ohio.

8. **Similar programs within 50 miles of Ohio State.**

There are no similar programs within 50 miles.

9. **Enrollment patterns of similar programs.**

UCLA has a similar program to the one here proposed. Their total undergraduate student population is approximately 10,000 fewer students than at Ohio State. However, their average number of bachelor degrees in mathematics awarded during the period 2004 – 2006 was 179.7, with 72.0 women, as compared with 95.0 at Ohio State, with 28.0 women. This suggests that the introduction of more applied degree tracks should attract more undergraduate majors and more diversity into the major population.

10. Job and study opportunities for graduates.

The new degree track in bio-mathematics will afford opportunities for research internships with the Mathematical Bio-Sciences Institute, which will prepare students for many careers in bio-mathematics and bio-statistics, including genetic code analysis and ecological resource management. The new degree track in financial mathematics will benefit from the established relationship of the current Actuarial Science program with major insurance companies, affording internships and career opportunities there as well as in the general risk management field. The new degree track in applied-discrete mathematics will be well-suited to place graduates with the National Security Agency, the Institute for Defense Analysis and other homeland security employers. There will of course remain the more traditional career tracks of graduate study in mathematics and related disciplines, and of secondary education in mathematics.

11. Licensure requirements for which this program will prepare students.

The Math Education track will continue to prepare students successful for the Praxis exams, required for licensure in secondary education. The Financial Math track, like the Actuarial Science degree track, will prepare students well for the actuarial licensure examinations.

III. GOALS AND OBJECTIVES

12. **Learning outcomes assessment plan for the major program**

ASSESSMENT PLAN

1. General and specific educational goals and objectives of the major.

The Ohio State University bachelor's degree in mathematics provides a comprehensive foundation of knowledge, skills, and methods for the pursuit of a wide variety of mathematics-related careers in business, government and education. The mission of the mathematics undergraduate program is to instill the methods of analytical reasoning and logical deduction, which are fundamental to the mathematical method, as well as to provide a basic knowledge of mathematical concepts and algorithms useful to mathematical problem-solving.

In order to accomplish this mission, the Department has identified the following list of specific education objectives for the undergraduate program:

1. Students will master the fundamental techniques of the differential and integral calculus of functions of one and several variables.
2. Students will acquire basic skills with systems of linear equations and the methodology of eigenvalue and eigenvector analysis.
3. Students will acquire facility at reading mathematical discussions and proofs.
4. Students will develop skills at constructing their own mathematical proofs using methods such as proof by contradiction, proof by contraposition, mathematical induction, wellordering, etc.

2. Methods used to assess whether the educational goals and learning objectives are being met

The general goals and objectives of the major listed above are assessed via written examinations in relevant courses. In particular, Goal 1 is assessed in the beginning calculus courses, Math 151 and 152. The Department has, for the past five years, instituted close coordination of these courses, with homework assignments and examinations set by the Course Coordinators. This guarantees uniformly high standards. A minimum course grade of C- is mandated for advancement to the next course in the sequence. Goal 2 is assessed in the linear algebra course (Math 568 or 571), while Goals 3 and 4 are assessed in Math 345.

Mathematics is a highly vertical discipline and therefore ongoing assessment of the mastery of these educational goals takes places in all subsequent mathematics courses in the program.

The Department also conducts exit surveys of mathematics majors, as well as studying the data collected in the University exit surveys, in order to assess student satisfaction with the program.

The Department tracks placement of graduates in graduate and professional schools and in professional employment, as another measure of the success of the program.

The Department has just begun to send out electronic surveys of mathematics alumni in order to assess the success of our program in the career development of our graduates. We will continue this as an ongoing assessment tool.

Specific tracks have additional external measures of assessment. For students in the Math Education Track, success on the Praxis examinations, in particular on the content examination, is a measure of the success of this track in the training of future secondary math educators. For students in the Financial Track, as in the current Actuarial Math major, success on the Actuarial Society Examinations is a measure of the success of this track in the training of future members of the financial and risk management professions.

New degree tracks, such as the new Applied Track, the Bio-Math Track, and the Applied Discrete Track, will be measured first by their success in attracting majors, second by our success in placing the graduates from these tracks in excellent post-graduation jobs or advanced degree programs, and finally by the alumni feedback indicating their level of satisfaction from the perspective of age and experience in the education which we provided them.

2. Time line over which the assessment plan will be implemented.

The assessment surveys and evaluation of data occurs on an annual ongoing basis. Needless to say, the most meaningful measures of success for the new tracks will not be available for many years, when we can assess the success in career placement of graduates and job satisfaction reported by alumni.

3. How outcomes information will be used to improve student learning and program effectiveness.

The Department of Mathematics is continually evaluating data on student success and satisfaction in order to improve our courses. The implementation five years ago of close coordination of the beginning calculus courses was a result of data suggesting lack of retention of knowledge by some calculus graduates, as evidenced in future mathematics courses, as well as in courses in sister disciplines, such as chemistry. There is work-in-progress at this moment to revise the syllabus and delivery methodology for the basic differential equations course, Math 415, based on data reported primarily by colleagues in the College of Engineering, concerning

failure of knowledge transfer from mathematics courses to engineering courses. Likewise the abstract algebra sequence is in the process of redesign in order to improve its relevance to future secondary math educators.

This process will continue with the new undergraduate tracks. The Undergraduate Committee of the Department of Mathematics oversees the evaluation of all courses, both new and existing. Representatives of the important programs (financial math, bio-math, applied math, honors, teacher education) serve on this Committee and provide ongoing monitoring of the successes and failures of the programs.

IV. RELATIONSHIP TO OTHER PROGRAMS

13. Current major and minor programs in the department and how they relate to the proposed revisions.

As noted above, the traditional major program remains unchanged. The new proposal offers greater variety of pathways to a bachelor's degree in mathematics.

14. Overlaps with other programs or departments within the university.

The Applied-Discrete Track requires students to earn a minor degree in Computer and Information Science. The other applied tracks require course work in allied disciplines. We have requested and obtained concurrences from the departments of Computer Science and Engineering, Electrical and Computer Engineering, and Mechanical Engineering, who have agreed to allow students pursuing one of our applied degree tracks to take courses in their discipline normally restricted to their own majors. (See attachments.) We have also consulted with and obtained concurrences from Biology, concerning the bio-math track.

15. Cooperative arrangements with other institutions and organizations that will be used to offer this program.

We have a letter of cooperation from Nationwide Insurance Company supporting our proposed Financial Math Track. We also have a letter of cooperation from the Director of the Mathematical Bio-Sciences Institute supporting our proposed Bio-Math Track and offering undergraduate research opportunities for participants.

16. Articulation arrangements with other institutions that will be in effect for the program.

No special arrangements are needed.

17. Use of consultants or advisory committees in the development of the program.

The general framework of the program was proposed by a subcommittee of the Undergraduate Committee of the Department of Mathematics, assisted by Rodica Barbu in the collection of data from benchmark institutions. The concept of greater flexibility of degree program was encouraged by our colleague, Peter March, currently Program Director for Mathematics at the National Science Foundation. March specifically recommended the program at UCLA as a model of a successful undergraduate degree program in mathematics. Our proposal is quite similar to this model, taking advantage of the unique strengths of the Ohio State University.

The Financial Math Track was designed by Professor Chunsheng Ban, director of the Actuarial Sciences Program, in consultation with colleagues at Nationwide Insurance Company, including Rick Evans. The Bio-Math Track was designed by a subcommittee of Math Department faculty, led by Dr. Chiu-Yen Kao, in consultation with the directorate of the Mathematical Biosciences Institute. The Applied Math Track was designed by a subcommittee of Math Department faculty, in consultation with College of Engineering colleagues. The Applied-Discrete Track was designed by Professors Tim Carlson and Akos Seress in the Math Department, in close consultation with Professors Bruce Weide and Neelam Soundarajan in CS&E.

18. Previously submitted proposals.

None.

19. Where students are drawn from.

As with the existing degree program, students will be drawn from the general population of undergraduate students at the Ohio State University. The steadily improving quality of the undergraduate population, together with the Statewide initiatives to encourage more majors in STEM disciplines, should couple well with the increased flexibility and attactiveness of the proposed degree tracks to attract increasing numbers of undergraduates into the program.

V. STUDENT ENROLLMENT

20. Indicate the number of students you anticipate will be admitted to the program each year.

Currently, there are approximately 70-75 students admitted to the mathematics program each year. We expect this number to rise gradually as the new degree options become established and publicized. We expect at least 100 majors admitted per year by four years hence.

VI. DEGREE REQUIREMENTS

21. Courses which constitute the requirements and other components of this program.

There are several alternative tracks for students pursuing an undergraduate degree in mathematics. These will be described in detail below. Students intending to pursue a masters or doctoral degree in mathematics should follow the traditional track, preferably the honors version thereof. Students should design their degree program in consultation with their faculty advisor, preferably before the end of their sophomore year. Students planning an Honors Contract in mathematics must take at least the 161H or 190H sequences and one other honors math sequence.

All tracks have a common core of required courses:

CORE REQUIREMENTS FOR ALL MATH MAJORS:

A. Calculus Sequence: 151, 152, 153, 254, or one of the accelerated or honors sequences (161, 162, 263; 161H, 162H, 263H; 190H, 191H, 264H).

B. Linear Algebra: 568 (or 571 or 520H)

C. Foundations of Higher Mathematics: 345

(waived for students who have taken 191H, and for students pursuing the Applied-Discrete Track)

DATA ANALYSIS REQUIREMENT

The B.A. degree requires one data analysis course as part of the G.E.C. However, it is recommended that all B.S. and B.A. math majors take Math 530 or 531H or Statistics 420, followed by Statistics 421. This is not a requirement of the major, but statistics is important for many of the best career opportunities available to mathematics majors.

DEGREE TRACKS:

There are six degree tracks available for students pursuing an undergraduate major in mathematics:

1. **Traditional Track**
2. **Education Track**
3. **Financial Track**
4. **Bio-Math Track**
5. **Applied Track**
6. **Applied-Discrete Track**

Each of these is described in detail in the following pages.

Note: A maximum of 3 hours of 593 or 693 may be used in any of these degree programs.

There is also a degree in **Actuarial Science,** which is technically distinct from a degree in mathematics, but which resides in the Department of Mathematics. No change is proposed for the actuarial science major.

1. Math Major: Traditional Track

The traditional track is intended for students seeking a strong foundation in classical mathematics, in particular for students intending to pursue graduate study in mathematics. Students planning to pursue a PhD. in mathematics are strongly encouraged to take the honors version of the math courses listed below, whenever possible.

In addition to the Core Requirements for all mathematics majors, the following are

Required Courses for the Traditional Track

- **D. Differential Equations:** 521H (or 255)
- **E. Abstract Algebra Sequence:** 590H-591H-592H (or 580-581-582)
- **F. Real Analysis Sequence:** 190H-191H (or 547-548-549)

Elective Courses

In addition to the above, students are required to complete a minimum of 15 hours selected from the list below.

a. Calculus on Manifolds	540H, 541H
b. Combinatorics	575
c. Complex Variables	522H (or 654 or 660 or 514)
d. Discrete Modeling	578
e. Geometry	507
f. History of Mathematics	504
g. Linear Algebra	572
h. Number Theory	576H, 577H (or 573)
i. Partial Diff. Eqns.	512
j. Probability	531H or 530 (or Stat 420)
k. Real Analysis	651-652-653
l. Statistics	Stat 421
m. Topology	655-656-657
n. Vector Analysis	264H (or 551 or 513)

Two sample programs are given on the next page. The first is particularly recommended for students intending to pursue graduate study in mathematics.

SAMPLE SCHEDULE (Honors Version)

Autumn	Winter	Spring
Math 190H	Math 191H	Math 264H
Autumn	Winter	Spring
Math 520H	Math 521H	Math 522H
Autumn	Winter	Spring
Math 590H	Math 591H Math 540H or 576H	Math 592H Math 541H or 577H
Autumn	Winter	Spring
Math 531H	Math 540H or 576H	Math 541H or 577H

Note: 540-541H and 576-577H are offered in alternate years.

- 187H/487H (Problem solving seminars) would be an excellent enhancement.

SAMPLE SCHEDULE (Non-Honors Version)

Autumn	Winter	Spring
Math 161H	Math 162H	Math 263H
Autumn	Winter	Spring
Math 345	Math568	Math 255
Autumn	Winter	Spring
Math 580	Math 581 Stat 420	Math 582 Stat 421
Autumn	Winter	Spring
Math 547 Math 507	Math548 Math 575	Math 549 Math 514

- 187H/487H (Problem solving seminars) would be an excellent enhancement.

2. Math Major: Education Track

The Education Track is designed for students seeking secondary education licensure in mathematics. A minimum GPA of 2.7 is required. In addition to the Core Requirements for all mathematics majors, the following are

Required Courses for the Education Track:

D. Differential Equations or Discrete Modeling: 255 (or 521H) or 578
E. Abstract Algebra Sequence: 580-581-582 (or 590H-591H-592H)
F. Real Analysis Sequence: 547-548-549 (or 190H-191H)

Elective Courses

In addition to the above, students are required to complete a minimum of 15 hours selected from the list below:

a. Geometry	507*
b. History of Mathematics	504*
c. Differential Equations	255 (or 521H), if not above
c. Discrete Mathematics	575
d. Probability	530 (or Stat 420* or Math 531H)
e. Statistics	Stat 421*
f. Number Theory	573 (or 576H, 577H)
g. Modeling	578*, if not above

SAMPLE SCHEDULE

Autumn	Winter	Spring
Math 151	Math 152	Math 153
Autumn	**Winter**	**Spring**
Math 254*	Math 255**	Math 345* Math 568*
Autumn	**Winter**	**Spring**
Math 580* Stat 420*	Math 581* Stat 421*	Math 582 Math 578*
Autumn	**Winter**	**Spring**
Math 547 Math 507*	Math 548	Math 549 Math 504*

* = required for admission to the O.S.U. M.Ed. program
** = recommended but not required
• 187H/487H (Problem solving seminars) would be an excellent enhancement.

3. Math Major – Financial Math Track

The Financial Math Track is designed for students seeking a career in quantitative finance or a related field. Students planning to pursue graduate studies in financial mathematics are strongly encouraged to take the honors versions of the mathematics courses listed below, whenever possible.

In addition to the Core Requirements for all mathematics majors, the following are

I. Prerequisite Courses:

Economics: Econ 200 and 201 (or 200H and 201H)
Accounting: Acct 310
Computer Science: CSE 200

II. Required Courses for the Financial Track:

D. Differential Equations: Math 255 (or 521H) **and** Math 512
E. Probability and Statistics Math 530 (or Math 531H or Stat 420), **and** Stat 421
F. Interest Theory: Math 618
G. Financial Economics: Math 632
H. Numerical Analysis: Math 607
I. Intro. to Math. Finance: Math 589
J. Computer Science: CSE 201 (or 202)
K. Finance: Bus-Fin 420 (or 620)
L. Practicum Seminar

M. Recommended Additional Courses:

The following courses could serve to enrich the required program in financial math:
Finance 722; Statistics 635, 645; Math 532, 547, 548, 549, 630, 631; Computer Science 221

SAMPLE SCHEDULE

Autumn	Winter	Spring
Math 151	Math 152	Math 153
CS&E 200	Econ 200	Econ 201
Autumn	**Winter**	**Spring**
Math 254	Math568	Math 255
Accounting 310	CS&E 202	Math 345
Autumn	**Winter**	**Spring**
Math 512	Stat 420	Stat 421
Math 618	Finance 620	Elective (Math 532)
Autumn	**Winter**	**Spring**
Math 589	Math 607	Math 632
		Practicum Seminar

4. Math Major – Bio-Math Track

In addition to the Core Requirements for all mathematics majors, the following are

Required Math-Related Courses

D. Differential Equations: 255(or 521H) and 512 (8cr.)
E. Prob. & Stat.: Stat. 420 (or Math 530 or 531H) and Stat. 421(8-10cr.)
F. Linear Algebra: 572 (waived for students who have taken 520H=571+572)(3cr.)
G. Numerical Analysis: 607 (or approved substitute)(5cr.)

Required Biology-Related Courses

H. Biology Sequence: Chem 121, Bio 113(or 115H), Bio 114 (or 116H)(15 cr.)
I. Math Biology Seminar: Math 350(3 cr.)
J. Advanced Biology courses: Bio 401, Bio 402 (8 cr.)

"Mathematics is applicable to many different aspects of biology, and new applications are continually being found. In order to allow students to choose the directions in which they wish to apply themselves, we have listed several options as electives. We fully expect that students will take the appropriate prerequisites associated with the courses they choose, and students will be advised accordingly."

Students will be required to obtain written approval, prior to their junior year, for their planned program of study from a faculty advisor, assigned by the Mathematics Counselors.

Elective Courses (9 credit hours)

In addition to the above, students are required to complete a minimum of 9 hours selected from the list below. Substitutions are permitted, but only with the written approval of the faculty advisor.

1. Biology:

Ecology & Evolution: EEOB 400 evolution (5cr., Bio 114 or 116H prereq.),
EEOB 503 introductory ecology (4cr.+2cr., Bio 113,114)
Molecular Biology: MG/EEOB 500 general genetics
(5cr., Bio 113 or 115H+5hrs biosciences prereq.),
Biochemistry 511 (5cr., chem. 123, 252 and 2 quarters of biological sciences)
Neurology: Neuro 300 (4cr., Bio 114, or 116H prereq.)

2. Mathematics:

Advanced ODE/Dynamical System	615, 616 (or 556, 557, when approved)
Analysis	547 (190H)
Algebra	580 (590H)
Complex Variables	514 (522H)
Discrete Modeling	578
Geometry	507

3. Suggested Courses in other fields:

Biochemistry: BC211, 212 (Prereq: Chem 102 or Chem 122)
Chemistry: Chem 231, 251, 252, 253 (Organic chemistry)
Chem 520, 521, 530 (Physical chemistry) (Prereq: Phys 133 or 113)
Physics: Phys 261, 262, 263 (Dynamics of particles and waves)
Phys 555, 656, 657 (Fields and waves) (Prereq or concur: Phys 261)

Note: The application of mathematics to biology is highly inter-disciplinary in nature, continually finding not only new applications within biological fields, but also new fields in which to apply mathematics. As such, we expect future students and interested faculty to propose courses, sequences, and tracks not listed here.

SAMPLE SCHEDULE (I)

Autumn	Winter	Spring
Math 151 CH 121	Math 152 Bio 113(115H)	Math 153 Bio 114(116H)
Autumn	Winter	Spring
Math 254	Math 255 Stat 420	Math 512 Math 345 Stat 421
Autumn	Winter	Spring
Math 571 Advanced Bio 1 (e.g. Bio 401)	Math 572 Math 607	Advanced Bio 2 (e.g. Bio 402) Math 350
Autumn	Winter	Spring
Elective Bio 1 (e.g. EEOB 400)		Elective Bio 2 (e.g. EEOB 503)

SAMPLE SCHEDULE (II)

Autumn	Winter	Spring
Math 151 CH 121	Math 152 Bio 113(115H)	Math 153 Bio 114(116H)
Autumn	Winter	Spring
Math 254	Math 255 Stat 420	Math 512 Math 345 Stat 421
Autumn	Winter	Spring
Math 571 Elective Math 1 (e.g. Math 615)	Math 572 Elective Math 2 (e.g. Math 616)	Math 350
Autumn	Winter	Spring
Advanced Bio 1 (e.g. Bio 401)	Elec. Math 3 (e.g. 547) (e.g. Math 547) Math 607	Advanced Bio 2 (Bio 402)

Math Major: Math Applicable to the Physical Sciences

This applied math option is intended for students seeking a strong foundation in mathematics and its application in physical science. Students will be required to obtain approval for their planned program of study from a faculty advisor prior to their junior year. The Mathematics Councilors will assign a faculty advisor to guide the student through the program. An honors version of the program is available – see the last sample program.

In addition to the Core Requirements for all mathematics majors, the following are

Prerequisite Courses:

- **D. Physics Sequence:** Phys 131, 132, 133 (or 131H, 132H, 133H).
- **E. Computer Programming**: CSE 202.

Required Courses for this Applied-Math Option:

- **F. Differential Equations:** 255, 512 (in some specializations, M415 can replace M255 – see sample programs).
- **G. Prob. & Stat.:** Stat. 420 or Math 530, and Stat. 421.
- **H. Linear Algebra:** 572 (waived for students who take 520H = 571+572).
- **I. Numerical Analysis:** 607.
- **J. Complex Variables:** 514.

Elective Courses

In addition to the above, students are required to complete a minimum of 9 hours in Group I and 9 hours in Group II.

Group I: Math courses

Analysis: 547, 548, 549.
Mathematical Principles in Science: 601, 602, 603.02.
Applied Differential Geometry: 665, 666.
Calculus of Variations and Tensor Calculus: 701.
Vector Analysis: 513 or 551.

Group II: Applications

The student should choose a coherent sequence of courses in some discipline outside of mathematics that makes significant use of mathematics. These disciplines may include chemistry, physics, statistics, and various areas of engineering. Some specific choices are listed below. Others may be chosen with the specific approval of your advisor.

Chemistry:

Chem. 121-122-123: General Chemistry.
Chem. 221: Analytical Chemistry.
Chem. 530: Quantum Chemistry.
Chem. 531: Statistical Mechanics and Thermodynamics.
Chem. 532: Thermodynamic Equilibrium and Chemical Kinetics.

SAMPLE SCHEDULE

Autumn	Winter	Spring
Math 151	Math 152	Math 153
Phys 131	Phys 132	Phys 133
	CSE 202	

Autumn	Winter	Spring
Chem. 121	Chem. 122	Chem. 123
Math 254	Math 255	Math 512
	Math 571	Math 572
		Math 345

Autumn	Winter	Spring
Math 547	Math 607	Math 512
Chem. 221	Stat 420	Stat 421
		Math 514

Autumn	Winter	Spring
Chem. 530	Chem. 531	Chem. 532
Math elective	Math elective	Math elective

Special notice: Students can accomplish the math and chemistry (B.A.) double major by adding the following classes;
3rd year – Chem. 251-252-253, along with the organic lab sequence.
4th year – Chem. 541.

Digital Signal/Image Processing:

ECE 205: Circuit Analysis.
ECE 301: Analysis and Design in Circuits and Electronics.
ECE 351: Systems I.
ECE 352: Systems II.
ECE 600: Introduction to Digital Signal Processing.

Students with a strong interest in this topic may consider taking the more advanced courses;
ECE 700: Digital Signal Processing.
ECE 707: Digital Image Processing.

SAMPLE SCHEDULE

Autumn	Winter	Spring
Math 151	Math 152	Math 153
Phys 131	Phys 132	Phys 133
	CSE 202	
Autumn	**Winter**	**Spring**
Math 254	Math 415	Math 345
	Math 571	Math 572
		Math 512
Autumn	**Winter**	**Spring**
		Math 514
Math 547	Math 607	Stat 421
ECE 205	Stat 420	ECE 301
Autumn	**Winter**	**Spring**
ECE 351	ECE 352	ECE 600
Math elective	Math elective	Math elective

Dynamics:

Mech. Eng. 410: Statics.
Mech. Eng. 430: Dynamics.
Mech. Eng. 501: Thermodynamics I.
Mech. Eng. 502: Thermodynamics II.
Mech. Eng. 503: Fluid Dynamics I.
Mech. Eng. 504: Fluid Dynamics II.

Students with a strong interest in this topic may consider taking the more advanced courses;

Mech. Eng. 731: Vibrations of Discrete Systems.
Mech. Eng. 734: Vibrations of Continuous Systems.
Mech. Eng. 735: Analytic Dynamics.

SAMPLE SCHEDULE

Autumn	Winter	Spring
Math 151	Math 152	Math 153
Phys 131	Phys 132	Phys 133
	CSE 202	

Autumn	Winter	Spring
Chem. 121	Math 415	Math 345
Math 254	Math 571	Math 572
		Math 512

Autumn	Winter	Spring
Math 547	Math 607	Math 514
Mech. Eng. 410	Stat 420	Stat 421
		Mech. Eng. 501

Autumn	Winter	Spring
Mech. Eng 502	Mech. Eng. 503	Mech. Eng. 504
Math elective	Math elective	Math elective

Physics:

Phys. 261: Dynamics of Particles and Waves I.
Phys. 262: Dynamics of Particles and Waves II.
Phys. 263: Dynamics of Particles and Waves III.
Phys. 621: Statistical Physics I.
Phys. 622: Statistical Physics II.
Phys. 644: Theoretical Mechanics.

Phys. 555: Fields and Waves I.
Phys. 656: Fields and Waves II.
Phys. 657: Fields and Waves III.

Phys. 631: Introductory Quantum Mechanics I.
Phys. 632: Introductory Quantum Mechanics II.
Phys. 633: Introductory Quantum Mechanics III.

SAMPLE SCHEDULE

Autumn	Winter	Spring
Math 151	Math 152	Math 153
Phys 131	Phys 132	Phys 133
	CSE 202	

Autumn	Winter	Spring
Math 254	Math 255	Math 512
	Math 571	Math 345
		Math 572

Autumn	Winter	Spring
Math 547	Stat 420	Math 514
Math 513	Math 607	Stat 421
Phys. 261	Phys. 262	Phys. 263

Autumn	Winter	Spring
Math elective	Math elective	Math elective
Phys. 621	Phys. 622	Phys. 664
or	or	or
Phys. 555	Phys. 656	Phys. 657
or	or	or
Phys. 631	Phys. 632	Phys. 633

Radio Wave Propagation:

ECE 205: Circuit Analysis.
ECE 311: Electro-Magnetics I.
ECE 312: Electro-Magnetics II.

Students with a strong interest in this topic may consider taking the following advanced courses;

ECE 711: Radiation from Antennas.
ECE 713: Elements of Radio Wave Propagation.
ECE 714: Radar Systems.

SAMPLE SCHEDULE

Autumn	Winter	Spring
Math 151	Math 152	Math 153
PH 131	PH 132	PH 133
	CSE 202	
Autumn	**Winter**	**Spring**
Math 254	Math 415	Math 345
	Math 571	Math 512
		Math 572
Autumn	**Winter**	**Spring**
Math 547	Math 607	Math 514
	Stat 420	Stat 421
Autumn	**Winter**	**Spring**
ECE 205	ECE 311	ECE 312
Math elective	Math elective	Math elective

Honors Program (Applied Track):

Students intending to pursue a PhD. in mathematics are strongly encouraged to take two quarters of real analysis, two quarters of abstract algebra and the honors version of the math courses listed below, whenever possible. To be eligible for the degree with honors, students must take one of the honors sequences in calculus, and at least one other honors math sequence.

Honors Courses:

A. **Calculus**: 161H, 162H, 263H replaces 151, 152, 153, 254 or 190H, 191H, 264H replaces 151, 152, 153, 254, 345, 547, 548, 549.
B. **Linear Algebra**: 520H replaces 571, 572.
D. **Physics**: Ph131H, Ph132H, Ph133H replaces Ph131, Ph132, Ph133.
F. **Differential Equations**: 521H replaces 512.
J. **Complex Variables**: 522H replaces 514.

Elective Honors Courses:

Applied Differential Geometry: 540H, 541H replaces 665, 666.
Vector Analysis: 264H replaces 513 or 514.

Math Major: Applied Discrete Option

The applied discrete math option is intended for students seeking a career in mathematics focusing on discrete mathematics and computation. This includes students intending to pursue a PhD in either combinatorics or mathematical logic. These students are strongly encouraged to take at least two algebra courses, two analysis courses, and the honors options of the course listed below whenever possible.

Students will be required to obtain written approval, prior to their junior year, for their planned program of study from a faculty advisor, assigned by the Mathematics Counselors.

In addition to the Core Requirements for all mathematics majors, the following are

Required Math-Related Courses
D. Combinatorial Mathematics and Graph Theory: Math 575
E. Discrete Mathematical Models: Math 578
F. Probability and Statistics: Math 530 or 531H (or Stat 420) and Stat 421
G. Either (i) or (ii) below:
(i) Algebra: Math 580-581-582 (or 590H-591H-592H); **and Coding Theory/Designs** (Math 585)

or

(ii) Set Theory and Mathematical Logic: Math 647-648-649

Required CIS Minor:

Students in the applied discrete math track are **required** to take a CIS minor including CSE 625 as one of the two elective courses in their minor program:

Required courses: CSE 221, 222, 321, 625; Math 345 or 366
Elective course: One chosen from CSE 541, 560, 625, 655, 660, 670, 675, 680

Recommended Additional Courses (depending on the student's special interest)
Computer Science and Engineering: CSE 725 (Computability and Unsolvability)

Industrial and Systems Engineering: ISE 702 (Mathematical Programming: Linear)

Linguistics: Lin 601 (Introduction to Linguistics)
Lin 680 (Formal Foundations of Linguistics)
Lin 681 (Algebraic Linguistics)
Lin 683 (Linguistic Semantics)

Mathematics: Math 573 (Elementary Number Theory)
Math 576H/577H (Number Theory through History)

Philosophy: Phil 650 (Advanced Symbolic Logic)
Phil 652 (Nonclassical Logic)

SAMPLE SCHEDULE (I)

Autumn	Winter	Spring
Math 151	Math 152	Math 153
	CSE 202	CSE 221
Autumn	Winter	Spring
Math 254	Math 568	Math 345
CSE 222		CSE 321
Autumn	Winter	Spring
Math 580	Math 581	Math 582
CSE 625	Math 575	CSE 655
Autumn	Winter	Spring
Math 530	Stat 421	Math 578
Math 585		

SAMPLE SCHEDULE (II)

Autumn	Winter	Spring
Math 151	Math 152	Math 153
	CSE 202	CSE 221
Autumn	Winter	Spring
Math 254	Math 568	Math 345
CSE 222		CSE 321
Autumn	Winter	Spring
Math 648	Math 649	Math 647
CSE 625	Math 575	CSE 655
Autumn	Winter	Spring
Math 530	Stat 421	Math 578

22. Minimum number of credits required for completion

55 credits within the degree track. This could be achieved by taking the honors traditional track and taking only the minimum number of required elective credits. In general our honors majors would take at least 70 credits of honors mathematics courses.

23. Average number of credits expected at completion

70 credits within the degree track. The non-honors traditional or education tracks would require at least 65 credit hours. The specialized tracks require a somewhat higher number of credit hours.

24. Estimated average number of credits taken per quarter by a typical student

15

25. Number of credits a student is required to take in other departments

This number varies considerably depending on the degree track. All students are required to complete the standard 60 GEC credit hours (of which 10 are Math 151, 152). This is all that is required of students in the traditional or education tracks, although all students are strongly recommended to take Statistics 421.

26. Number of credits a student might take as an elective in other departments.

If a student takes 70-75 credits in mathematics and 51 additional GEC credits, this would allow the student to take 60 – 65 elective credits in other departments.

27. Other degree requirements

None.

28. Specialized professional associations from which accreditation will be sought.

This is a modification of an existing degree program in mathematics. The education track remains unchanged from the existing track, which is consistent with Ohio State standards for licensure in secondary mathematics education. No other accreditation is required.

29. Number and qualifications of full-time and part-time faculty.

Since this is not a new major, the faculty is well-established. The current size of the full-time faculty is 55. This is supplemented by a varying number of postdoctoral faculty. The current number is 25. All of the regular and postdoctoral faculty have doctoral degrees in mathematics and have been carefully vetted for their excellence as researchers in mathematics.

30. Existing facilities and equipment

Since this is not a new major, the department facilities and equipment are well-established and fully functioning.

31. Additional university resources required

The Department of Mathematics is at a historic (for the past 40 years) low in the number of regular faculty. The University has committed to an increase of 10 in the number of regular faculty. Nevertheless, it will be possible to begin the implementation of these new degree tracks with the current faculty and staff. If student demand grows as anticipated, then more faculty (and perhaps staff as well) will be required. This will be justified by the increased revenue generated.

32. Program description as it would appear in the appropriate college bulletin.

The Ohio State Department of Mathematics undergraduate degree program offers an intensive education in the fundamentals of calculus, linear algebra, and the foundations of logical reasoning. Building on this, students have the opportunity to pursue several avenues of deeper study, directed towards the many career opportunities available to mathematics professionals. The traditional track offers a solid preparation for students wishing to pursue advanced degrees in mathematics, as well as the logical underpinning for other professional careers, such as law and medicine. The education track provides the deep understanding of K-12 mathematics needed by professional math educators at the secondary level. The finance track provides a basic knowledge of probability and statistics with applications to risk analysis. The bio-math track weds mathematics to the expanding domain of applications to the biological, ecological, and medical sciences. The applied-discrete track provides a foundation of logic and discrete mathematics, tied to a minor in computer science. The applied track offers a firm grounding in differential equations and numerical analysis, linked to applications in chemistry, physics, and engineering.

Note: See appendix for letters of support and concurrence.