TO: Randy Smith, Vice Provost for Academic Programs
FROM: Jennifer Schlueter, Faculty Fellow for Curriculum, Graduate School
DATE: 16 May 2018
RE: Proposal to create a new Graduate Minor in Mathematics

The Department of Mathematics in the College of Arts and Sciences is proposing a new Graduate Minor in Mathematics. The proposed minor responds to growing enrollment in Mathematics coursework by students from disciplines as varied as computer science, engineering, philosophy, and the biological sciences. It will require 15 credit hours of approved graduate-level mathematics courses.

The proposal was received by the Graduate School in December 2017. It was reviewed by the combined GS/CAA Curriculum subcommittee, chaired by Faculty Fellow Jennifer Schlueter, in March 2018, and returned to proposers for revision. Revisions were received on 5 April 2018 and approved by the subcommittee; it was forwarded to the Graduate Council for their review that same day. The proposal was reviewed and approved at the Graduate Council by evote on 11 May 2018.

From:	Kerler, Thomas
To:	Schlueter, Jennifer
Cc:	Toft, Jill A.; Smith, Randy
Subject:	Re: proposal for a graduate minor in Mathematics
Date:	Tuesday, March 27, 2018 9:07:02 PM
Attachments:	Grad_Minor_CAA-REsponse_Cover_Letter_2018_03_27.pdf

Dear Professor Schlueter,

Please find attached the requested cover letter with responses to your questions.

Best regards, Thomas Kerler

On 03/22/2018 11:54 AM, Schlueter, Jennifer wrote:

> Dear Professor Kerler:
>
> The combined Grad School/CAA curriculum subcommittee, which I chair as Faculty Fellow, has reviewed your proposal for a new Graduate Minor in Mathematics. They were very enthusiastic about the ways this proposed Minor fills a distinct need in graduate education at OSU. However, we had a few questions and requests for clarifications. Please take a look and offer your responses to each query in a cover letter to the proposal.
>
> 1. Can you clarify the calculations of credit hours in the "Proposed Curriculum and Requirements" section of your proposal? The committee had a difficult time understanding why you stipulate 4 *courses* at the 5000 level or higher as well as 9 *credit hours* from letter graded courses at the 5000 or 6000 level. We think you mean: 15 credit hours required for the minor, 9 credits at the 5000 level or higher, no more than 3 S/U. Is this correct? (And we do indeed recognize the deep irony of asking for a Math program to clarify its math!!)
> 2. Why is the Minor proposed to be open only to PhD students?
> 3. It appears that the Minor as proposed is highly customizable, with some recommended pathways for students coming from various programs. This seems to potentially present a large administrative workload, as each customized plan must be approved by the newly created Graduate Minor Chair. We see, in the "Enrollment" section of the proposal, that enrollment will be limited to a max of 15 students with a potential for revisiting the structure of the Minor if demand exceeds this. Can you offer a sentence or two on why this is your approach with creating this Minor?
>
> Please let me know if you have any questions. Upon receipt of your revisions, the subcommittee will revisit and, if satisfied, forward on to the Graduate Council for their review and approval. From there, the proposal moves to CAA for theirs. I'll keep you posted as it moves along.

Best,
Jen

Jennifer Schlueter, PhD
Associate Chair, Department of Theatre
Associate Professor | Lab Series Coordinator | Editor, Theatre/Practice
Faculty Fellow, Curriculum, Graduate School
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THE OHIO STATE UNIVERSITY

College of Arts and Sciences

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March 27th, 2018

Professor Jennifer Schlueter
Combined Graduate School – CAA Curriculum Subcommittee
The Ohio State University

RE: Graduate Minor in Mathematics – Committee Response.

Dear Professor Schlueter,

Please find below our responses to your questions from March 22nd, 2018:

Can you clarify the calculations of credit hours in the "Proposed Curriculum and Requirements" section of your proposal? The committee had a difficult time understanding why you stipulate 4 courses at the 5000 level or higher as well as 9 credit hours from letter graded courses at the 5000 or 6000 level. We think you mean: 15 credit hours required for the minor, 9 credits at the 5000 level or higher, no more than 3 S/U. Is this correct?

Our department distinguishes between 5000/6000 level courses (master and beginning doctoral level) on the one hand and 7000/8000 level courses (advanced doctoral and topics/research level). The rules require 4 courses from either of these two groups of which 9 credits must be from the former group.

As to the rationale for the first rule – we have several courses at the 5000+ level that are 5 credit courses (2 hours of which are typically problem-solving recitations). Without the 4 course requirement, a student could take 3 such courses and obtain a minor. The GSC felt this 3 course path is not sufficient to warrant a minor. This is the reason for the 4 course minimum requirement.

As to the rationale for the second rule – mathematics courses at the 7000+ level typically have only modestly graded homework and usually no in-class exams. Grades are often based primarily on classroom participation and/or presentations by the student.

The GSC felt that, for non-math PhD students seeking a minor, some portion of the courses should include rigorous homework, problem solving, and exams. This is the reason for the requirement of 9 credit hours at the 5000- or 6000-level.

Why is the Minor proposed to be open only to PhD students?

We want to err on the side of caution in regard to preparations and time commitment of students pursuing the minor. Specifically, we would like to avoid attracting students to our program who earn poor grades in most mathematics courses or who start but not finish the

minor due to time limitations of their main degree. PhD students tend to be better prepared and have greater scheduling flexibilities than master students, so they will be less likely to over-commit in either level of study or time.

The minor has also been designed in response to specific demands of potential students, and all of those have been from doctoral students thus far. The GSC will consider special cases of especially well prepared master students with carefully designed study plans that credibly combine schedules for both degrees.

It appears that the Minor as proposed is highly customizable, with some recommended pathways for students coming from various programs. This seems to potentially present a large administrative workload, as each customized plan must be approved by the newly created Graduate Minor Chair. We see, in the "Enrollment" section of the proposal, that enrollment will be limited to a max of 15 students with a potential for revisiting the structure of the Minor if demand exceeds this. Can you offer a sentence or two on why this is your approach with creating this Minor?

The minor degree aims to serve a wide range of student populations and disciplines on campus. They have been enumerated and explained in detail in the proposal. As illustrated via the sample schedules the most relevant mathematical topics and the way mathematics is most effectively connected varies considerably from discipline to discipline. We thus decided on a highly variable curriculum. The current enrollment cap is precisely due to our concerns about the potential administrative burden on the Grad Minor chair.

If it turns out that most students opt to take one of the pre-designed sequences, then we can expand the cap. If however most of the students end up designing their own sequence of courses, requiring more work from the GM chair, then we might keep the enrollment small while we decide on how to proceed.

Please let us know if you have more questions and thank you again for your consideration of our proposal.

Sincerely,

Thomas Kerler
Professor & Vice-chair
Department of Mathematics

ORIGINAL PROPOSAL BEGINS ON NEXT PAGE

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December 9th, 2017

Graduate Council
250 University Hall

RE: Proposal for a Graduate Minor in Mathematics.

Dear Colleagues,

On behalf of the Graduate Studies Committee (MGSC) of the Department of Mathematics I am pleased to submit a proposal for a new Graduate Minor in Mathematics via upload to the curriculum.osu.edu system. The proposal was approved by the MGSC on March 3rd of this year and is support by our graduate faculty.

The uploaded proposal includes a rationale for the minor, a description of the proposed curriculum, an outline of the administrative arrangements to support the new minor, and enrollment plans and estimates. In addition, we have attached an advising sheet to be used by students and advisors of the minor.

Thank you very much for your consideration of our proposal.

Sincerely,

Thomas Kerler
Professor & Vice-chair
Department of Mathematics

PROPOSAL FOR A GRADUATE MINOR IN MATHEMATICS

The Graduate Studies Committee (MGSC) of the Department of Mathematics is proposing a new Graduate Minor in Mathematics (GM). The proposal was approved by the MGSC on March 3rd, 2017.

Rationale

Graduate level mathematics courses have seen a steady increase in enrollment by graduate students from other programs at the Ohio State University (OSU) over the past years.

Notably, students from Computer Science and also other engineering departments frequently visit our master and doctoral level courses in topology and geometry, as problems in spatial modeling or topological data analysis require more and more sophisticated mathematical background. Students from Statistics routinely benefit from our advanced courses in probability theory and combinatorics. The Mathematics department also has a large faculty group in mathematical biology, and co-hosts the Mathematical Biosciences Institute. As a result, the department provides and teaches courses of great interest to students in life science departments who want to acquire the skills needed for mathematical modeling. Further examples include students from Philosophy attending logic and foundational courses, as well as students studying theoretical physics attending a broad range of graduate mathematics courses.

In recent times, one or two students each year manage to earn an MS degree in our program. However, by our estimate, many more students complete substantial graduate coursework in mathematics, without having this recognized in an official manner on their transcripts. There is also no good mechanism currently in place that would allow the mathematics department to advise these students on what mathematics courses would be appropriate and helpful to them.

With the proposed GM we aim to allow doctoral students from other programs, who have taken graduate level mathematics classes, but do not chose to obtain an MS degree, to have their advanced training in mathematics officially certified. The GM would create a framework to better guide such students through our course offerings, and, more generally, provide incentives for talented students to acquire knowledge in graduate level mathematics -- knowledge that is becoming increasingly relevant in many other areas of science.

Eligibility

The proposed minor is open only to *doctoral* students in any graduate program at OSU. Other degree students (JD, MD, MS, MA, etc.) may be considered in special circumstance with the approval of the MGSC.

Students seeking to earn the GM further need to adhere to the enrollment, approval, and supervision process described in the sections on administration and enrollment below. Students also need to be in good academic standing with the university and their home programs.

Proposed Curriculum and Requirements

In order to obtain a GM, a student is required to complete a minimum of **15 credit hours** of approved graduate level mathematics courses. A complete set of these courses is listed in the appendix. An approved curriculum must further fulfill the following requirements:

- At least **4** mathematics courses at the 5000-level or higher must be counted towards the GM requirements.
- All courses counted towards the GM must be passed with a grade of B or better, or an S for S/U graded courses, in compliance with Graduate School rules (Handbook, § 8.4).
- At most **3** credit hours of S/U graded courses may be counted towards the GM.

- At least **9** credit hours of the coursework counted towards the GM must be from letter graded mathematics courses at the 5000 or 6000 level.
- Group study courses (5194, 6194), internship courses (6191) and graduate research courses (6998, 6999, 7998, 8998, 8999) are not allowed to count towards the GM.
- The study plan needs to be approved by the department.

S/U graded courses include independent studies courses, research and internship courses, as well as 7000-level courses with the .02-decimalization.

The requirements above allow nearly all graduate mathematics courses to count towards the GM, in order to respond to the wide range of mathematical topics found in quantitative disciplines, and the observed outside participation across our entire course offerings.

This is balanced with the stipulation that at least 60% of the coursework is from seriously graded courses with substantial skill training based on homework and exams, as well as the approval of study plans as described below. Courses beyond the 6000 level can be counted towards the 9 hours from the fourth item above only with special permission by the GSC. A respective petition to the GSC will require evidence that a 7000 or 8000 level course applies sufficiently rigorous skill-assessments and grading standards (in a manner comparable to a 5000 or 6000 level course), and that the student has adequate preparations to takes the course.

Administration & Approval of Study Plans

The administration of the GM will be chiefly the responsibility of the MGSC with logistic and clerical assistance by the Graduate Coordinator (GC) and further oversight by the Vice-chair for Graduate Studies (VCG).

To this end the MGSC will appoint each year a *Graduate Minor Chair* (GMC) from the Mathematics graduate faculty.

The principal responsibility of the GMC is the approval, on behalf of the MGSC, of study plans in accordance with the stated rules. Every student enrolling in the GM needs to confer with the GMC in order to discuss a plan of study in accordance with the general rules stated above. The GMC needs to approve the plan of study as well as coordinate later adjustments with the MGSC and the Graduate School.

The sample study plans listed below provide a guide for the GMC, and illustrate some types of plans that would be acceptable and beneficial for a broad range of students with reasonable mathematical background. More advanced options may require more careful evaluation of preparations, and more substantial deviations might require the GMC to consult with the MGSC.

The GMC may also coordinate such approvals with other graduate faculty in the department with better knowledge of a particular specialization. Also, the GMC may contact the GSC chair of the student's home department if there are doubts about the student's academic standing in the home program.

The course requirements will be recorded in the attached Advising Sheet which will be signed by the GMC upon completion, and collected by the GC. The VCG will be informed by the GC and GMC of the completion, and will approve the transcript designation form submission by the student on gradforms.osu.edu following the Graduate School process. The GMC will prepare annual reports of earned GM's and submit them to the MGSC.

Enrollment

Before enrollment students need to have their study plan approved by the GMC. Previously taken courses may count towards the GM requirements. Students are asked to present the most recent Advising Report to the GMC for the proper evaluation of their background, the adequacy of the study plan, and their academic standing. The GMC will inform the MGSC chair, the VCG, and the GC of the approval.

The student follows the Graduate Schools online application procedures (via gradforms.osu.edu) and the VCG will approve the application subject to GMC approval and possible further departmental criteria. The online process involves approval by the Graduate School and electronic communication with the student and the student's advisor.

The department expects to enroll about 5-10 students in the GM during the initial phases of the program. The total number of students enrolled will be limited to 15, mainly in order to be able to guarantee an orderly and sustainable process, both administratively and in terms of academic oversight. If there is a demand beyond this number, the department will reevaluate the administrative procedures and requirements for the GM.

The GC and VCG will also monitor long-time enrollment in the GM. If a student has not completed their GM requirements within 3 years of the initial application, the progress of the students will be reevaluated, which might result in disenrollment.

Phase-In

The GM will be open to students who have started enrollment into their respective doctoral program no earlier than 13 months before the approval and inception of this degree program. (So, if, for example, the minor is approved by Autumn 2018, students should not have been enrolled before Autumn 2017). Retroactive course credits and exceptions are at the discretion of the MGSC.

Sample Curricula

The following sample curricula were proposed by mathematics faculty after consultation with colleagues from other departments, and were considered as adequate by the MGSC. They may, thus, be considered as pre-approved assuming adequate preparation by the student. The curricula are organized by specialization of the student, and the separation into first and second year is meant only as a suggestion. Students whose programs require candidacy by the end of their second year are encouraged to either complete accelerated versions of these curricula in their first two years or, after candidacy, substitute 8999 hours in their program by GM electives with permission of their departments.

1. Engineering & Physics

Background in advanced calculus and differential equations at the 4000-level.

First year: Math 5101, 5102

Second year: Math 5756, 5757

Third year: Math 5451

2. Economics & Finance

Required background in calculus and probability theory.

First year: Math 5632

Second year: Math 5633, 5634

Third year: Math 5635, 5637

3. Philosophy & Foundations

Background in advanced calculus and linear algebra.

First year: Math 5111, 5001

Second year: Math 5201, 5051

Third year: any Math 6001-6004 course

4. Life Science Departments

Background in calculus and life sciences.

First year: Math 5401, 5402

Second year: Math 5660, 5602

Third year: 5651 or 6601

(or any five of the six listed courses)

5. Statistics

Curricula have further sub-specializations depending on the student's interest. Doctoral students in statistics should have all prerequisite preparations. Foundational courses for *all* sub-specializations:

(First and second year): Math 5201, 5202 and Math 5101

One or two additional courses depending on sub-specialization (third year):

- *Discrete data analysis and optimization*:
  Math 6501, Math 5601, or Math 5603
- *Shape analysis*:
  Math 5702, Math 6701, or Math 6702
- *Nonparametric function estimation*:
  Math 5102, Math 5601, Math 5603
- *Probability*:
  Math 6501, Math 6502, or Math 8250

6. Computer Science

Students are expected to have solid background in calculus and linear algebra. There are three proposed curricula depending on the student's sub-specialization and interests.

- *Computational Geometry and Topology*:
  First year: Math 5702, 5801
  Second year: Math 6501, 6502
  Third year: Math 8710 or 8800
- *Distributed computing/temporal logic*:
  First year: Math 5051 and any one of Math 6001-6004
  Second year: Any one of Math 6001-6004
  Third year: Math 6251, 6252
- *Nonparametric function estimation*:

First year: Math 5201, 5202
Second year: Math 6251, 6252
Third year: One of Math 6501, 6502, or 7211

Attachments

- Cover Letter by VCG
- Advising Sheet

Appendix: Mathematics Graduate Level Courses

Course #	Course Title	Credits
5001	Introduction to Set Theory	3.0
5051	Introduction to Mathematical Logic	3.0
5101	Linear Mathematics in Finite Dimensions	3.0
5102	Linear Mathematics in Infinite Dimensions	3.0
5111	Algebra I	5.0
5112	Algebra II	5.0
5152	Introduction to Number Theory with Applications	3.0
5168	Introduction to the Finite Element Method	3.0
5201	Introduction to Real Analysis I	5.0
5202	Introduction to Real Analysis II	5.0
5221	Introduction to Complex Analysis	3.0
5251	Complex Variables and Applications	3.0
5401	Applied Differential Equations I	3.0
5402	Applied Differential Equations II	3.0
5421	Mathematics of Infectious Disease Dynamics	3.0
5451	Calculus of Variations and Tensor Calculus	3.0
5520H	Honors Linear Algebra and Differential Equations	5.0
5522H	Honors Complex Analysis	5.0
5529H	Honors Combinatorics	5.0
5530H	Honors Probability	5.0
5540H	Honors Differential Geometry	5.0
5576H	Honors Number Theory	5.0
5590H	Honors Abstract Algebra I	5.0
5591H	Honors Abstract Algebra II	5.0
5601	Essentials of Numerical Methods	3.0
5602	Computational Partial Differential Equations	3.0
5603	Numerical Linear Algebra	3.0
5630	Life Contingencies I	3.0
5631	Life Contingencies II	3.0

Course #	Course Title	Credits
5632	Financial Economics for Actuaries	3.0
5633	Loss Models I	3.0
5634	Loss Models II	3.0
5651	Mathematical Modeling of Biological Processes	3.0
5660	Integrated Molecular and Cellular Biology for Non-Biologists	5.0
5702	Curves and Surfaces in Euclidean Three Space	3.0
5756	Mathematical Methods in Relativity Theory I	3.0
5757	Mathematical Methods in Relativity Theory II	3.0
5801	General Topology and Knot Theory	3.0
6001	Advanced Mathematical Logic I: Proof Theory	3.0
6002	Advanced Mathematical Logic II: Model Theory	3.0
6003	Advanced Mathematical Logic III: Set Theory	3.0
6004	Advanced Mathematical Logic IV: Computability Theory	3.0
6111	Abstract Algebra I	5.0
6112	Abstract Algebra II	5.0
6151	Commutative Algebra	3.0
6152	Non-Commutative Algebra	3.0
6193	Individual Studies in Mathematics	
6211	Real Analysis I	5.0
6212	Real Analysis II	5.0
6221	Complex Analysis I	3.0
6222	Complex Analysis II	3.0
6251	Theory of Probability I	4.0
6252	Theory of Probability II	4.0
6411	Ordinary Differential Equations I	3.0
6451	Partial Differential Equations I	3.0
6501	Combinatorics and Graph Theory I	3.0
6502	Combinatorics and Graph Theory II	3.0
6601	Numerical Methods in Scientific Computing I	4.0
6602	Numerical Methods in Scientific Computing II	4.0
6701	Differentiable Manifolds	3.0
6702	Differential Geometry	3.0
6801	Algebraic Topology I	3.0
6802	Algebraic Topology II	3.0
7121.01	Algebraic Number Theory	3.0
7121.02	Algebraic Number Theory	3.0
7122.01	Analytic Number Theory	3.0
7122.02	Analytic Number Theory	3.0
7141	Algebraic Geometry I	3.0
7142	Algebraic Geometry 2	3.0
7161.01	Lie Algebras	3.0

Course #	Course Title	Credits
7161.02	Lie Algebras	3.0
7162.01	Lie Groups and Representation Theory	3.0
7162.02	Lie Groups and Representation Theory	3.0
7193	Individual Studies in Mathematics	
7211	Functional Analysis I	3.0
7212	Functional Analysis II	3.0
7221.01	Ergodic Theory I	3.0
7221.02	Ergodic Theory I	3.0
7222.01	Ergodic Theory II	3.0
7222.02	Ergodic Theory II	3.0
7412.01	Ordinary Differential Equations II	3.0
7412.02	Ordinary Differential Equations II	3.0
7413	Ordinary Differential Equations III	3.0
7452	Partial Differential Equations II	3.0
7453	Partial Differential Equations III	3.0
7611	Computational Partial Differential Equations I	3.0
7612	Computational Partial Differential Equations II	3.0
7651	Applied Complex Variables and Asymptotics I	3.0
7652	Applied Complex Variables and Asymptotics II	3.0
7711	Riemannian Geometry	3.0
7721	Kahler Geometry	3.0
7811.01	Homotopy Theory	3.0
7811.02	Homotopy Theory	3.0
7851	Differential Topology I	3.0
7852	Differential Topology II	3.0
8000	Topics in Foundations of Mathematics	3.0
8110	Topics in Algebra	3.0
8120	Topics in Number Theory	3.0
8140	Topics in Algebraic Geometry	3.0
8160	Topics in Representation Theory	3.0
8210	Topics in Real Analysis	3.0
8220	Topics in Complex Analysis	3.0
8250	Topics in Probability Theory	3.0
8300	Topics in Financial Mathematics	3.0
8410	Topics in Ordinary Differential Equations	3.0
8420	Topics in Partial Differential Equations	3.0
8500	Topics in Combinatorics	3.0
8610	Topics in Applied Mathematics	3.0
8650	Topics in Mathematical Biology	3.0
8710	Topics in Differential Geometry	3.0
8750	Topics in Lie Theory	3.0
8800	Topics in Topology	3.0

Graduate Minor in Mathematics
Advising Sheet

Prerequisites:

- Doctoral student in an Ohio State graduate program.
- In good academic standing with the university and the home program.

Requirements:

- Complete **15 credit hours** of **approved** graduate level mathematics courses (consult webpage).
- At least **4** mathematics courses at the 5000-level or higher must be counted towards the GM requirements.
- All courses counted towards the GM must be passed with a grade of B or better or an S for S/U graded courses.
- At most **3** credit hours of approved S/U graded courses may be counted towards the GM.
- At least **9** credit hours of the coursework counted towards the GM must be from letter graded mathematics courses at the 5000 or 6000 level.

Study Plan:

The study plan needs to be completed by the student with approval of the Graduate Minor Chair (GMC) before enrolling. An Advising Report should be presented to the GMC. Further the form needs to be completed with grades and adjustments and signed by the GMC for the final approval of the minor transcript designation.

	Course #	Abbr Title	Semester/Year	Credit Hrs	Grade
1					
2					
3					
4					
5					
6					
			Last	**Total**	**GPA**

Approval:

Graduate Minor Form - GMC Approval (Study Plan & Enrollment):

_____Date:

Graduate Minor Transcript Designation - GMC Approval (Grades & Requirements):

_____ Date:

Suggested Curricula

1. Engineering & Physics

First year: Math 5101, 5102

Second year: Math 5756, 5757

Third year: Math 5451

2. Economics & Finance

First year: Math 5632,

Second year: Math 5633, 5634

Third year: Math 5635, 5637

3. Philosophy & Foundations

First year: Math 5111, 5001

Second year: Math 5201, 5051

Third year: any Math 6001-6004 course

4. Life Science Departments

First year: Math 5401, 5402

Second year: Math 5660, 5602

Third year: 5651 or 6601

(or any five of the six listed courses)

5. Statistics

- *Discrete data analysis and optimization*:
  Math 6501, Math 5601, or Math 5603
- *Shape analysis*:
  Math 5702, Math 6701, or Math 6702
- *Nonparametric function estimation*:
  Math 5102, Math 5601, Math 5603
- *Probability*:
  Math 6501, Math 6502, or Math 8250

6. Computer Science

- *Computational Geometry and Topology*:
  First year: Math 5702, 5801
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- *Distributed computing/temporal logic*:
  First year: Math 5051 and any of Math 6001-6004
  Second year: Math 6251, 6252
- *Nonparametric function estimation*:
  First year: Math 5201, 5202
  Second year: Math 6251, 6252
  Third year: One of Math 6501, 6502, or 7211