THE COLLEGE OF
WOOSTER

The Mathematics Major's Handbook

Department of Mathematics
The College of Wooster
(updated Fall 2013)

Mathematics Faculty and Their Areas of Expertise

Jennifer Bowen	Abstract Algebra, Nonassociative Rings and Algebras, Jordan Algebras, Knot Theory
James Hartman	Linear Algebra, Magic Matrices, Involutions, Statistics, Operator Theory
Matthew Moynihan	Abstract Algebra, Combinatorics, Permutation Enumeration
R. Drew Pasteur	Differential Equations, Mathematics in Biology/Medicine, Sports Data Analysis
Pamela Pierce	Real Analysis, Functions of Generalized Bounded Variation, Convergence of Fourier Series, Undergraduate Mathematics Education, Preparation of Pre-service Teachers
John Ramsay	Topology, Algebraic Topology, Knot Theory, Operations Research
Robert Wooster	Analysis, Probability, Applications of SDEs, Agent Based Modeling

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I. Mission Statement and Learning Goals

Mathematics Department Mission Statement

The Mathematics Department's mission is to provide quality academic programs in mathematics that will allow students to prepare for graduate work and for employment in mathematics-related positions. Students will develop their analytical and problem solving skills while learning about the beauty of mathematics. In addition to providing specific content knowledge in mathematics, the mathematics program will develop the strong communication skills that are necessary in today's society. We will also strive to provide courses that will serve the needs of other departments and programs within the college.

Learning Goals for the Mathematics Major

The following five goals are what the department expects majors to achieve by the end of their course of studies.

1. **Communication**
   Students should be able to read and understand mathematical statements as well as express mathematical ideas with precision and clarity both orally and in writing.

2. **Content**
   Students should know the fundamental concepts, definitions, theorems and techniques of calculus and linear algebra. In addition, students should demonstrate competence in several specific areas of both pure and applied mathematics.

3. **Problem Solving/Reasoning**
   Students should be able to reason mathematically using graphical, numerical, and symbolic points of view, write sound proofs, and use technology appropriately to solve mathematical problems.

4. **Connection**
   Students should be able to synthesize material from multiple perspectives and make connections between different areas of mathematics.

5. **Independent and Collaborative Learning**
   The department acknowledges the importance of working together in teams to solve complex problems, and at the same time we hope to develop a culture of independence so that students will be able to approach and solve problems independently. Students will demonstrate skills in both of these areas.

II. Curriculum

Introductory Calculus and Linear Algebra
111. Calculus and Analytic Geometry I (or 108. Calculus with Algebra B)
112. Calculus and Analytic Geometry II

211. Linear Algebra
212. Multivariate Calculus

Applied Mathematics
219. Special Topics
221. Differential Equations
223. Combinatorics and Graph Theory
225. Mathematical Modeling
227. Operations Research
229. Probability and Statistics I

Introductory Proof Writing
215. Transition to Advanced Mathematics [(W) Writing Intensive]

Problem Solving
279. Fall Problem Seminar – preparation for the Putnam Competition
279. Spring Problem Seminar – Exploratory Mathematics or preparation for the Modeling contest

Pure Mathematics
319. Special Topics
327. Numerical Analysis
329. Probability and Statistics II
330. Topology
332. Real Analysis I
333. Real Analysis II
334. Abstract Algebra I
335. Abstract Algebra II
336. Functions of a Complex Variable

Senior Independent Study
451. Senior Independent Study (I.S.) – Semester One
452. Senior Independent Study (I.S.) – Semester Two

III. Requirements for the Major

A major in mathematics requires completion of the following thirteen courses, with grades of C- or better in each course:

- One of MATH 111 or 108
- MATH 112
- MATH 211
- MATH 212
- MATH 215
- CSCI 100 *(Scientific Computing)*
- Two upper-level applied math courses: MATH 219, 221, 223, 225, 227, or 229
- Two upper-level pure math courses: MATH 319, 327, 329, 330, 332, 333, 334, 335, or 336
- One elective full-credit Mathematics course numbered above 215
- MATH 451: Senior Independent Study
- MATH 452: Senior Independent Study

The mathematics program does not include a Junior Independent Study (401) course. The College requirement for a third unit of Independent Study is satisfied through the independent work done as part of the courses numbered above 200, which are taken to fulfill the requirements of the major.

At most, two courses of advanced placement may be counted toward a major or minor.

Majors are encouraged to pursue a minor and/or second major in related fields, such as the natural sciences, computer science, economics, or education. Double majors write a multidisciplinary I.S. thesis, typically using mathematics as a tool to better understand a problem in the other field. Students considering a mathematics major should discuss their plans with a member of the department, ideally during their first year as a student.

Table 1: Recommended classes double majors or minors in other fields.

Major or Minor	Recommended Classes
Biology, BCMB, Environmental Studies, Neuroscience, Geology	*221, 225, 229*
Chemistry	*221, 225*
Computer Science	*223, 229, 327*
Economics	*221, 227, 229, 329*
Education (minor)	*225 or 227 (required), 229 (required), 334 (required)*
Physics, Pre-Engineering	*221, 225, 327*
Political Science	*227, 229, 329*

Table 2: Recommended classes for majors preparing for graduate school.

Field	Recommended Classes
Pure mathematics	*221, 229, 215, 330, 332, 334, and 336*
Applied mathematics	*221, 225 or 227, 229, 327, 332, also consider 329*
Computational mathematics	*221, 223, 225, 327, 332, also consider CSCI 200 and CSCI 220*
Financial mathematics	*221, 227, 229, 329, 332, also consider ECON 210 and ECON 224*
Statistics	*229, 329, also consider 221 and 227*

Recommended Timeline for the Mathematics Major

The courses in the department are systematically related; skills and knowledge developed in some courses are presupposed and/or integrated into other courses. Thus, there is a timeline or schedule that helps students most effectively progress through the major. In general, we expect students to follow one of these schedules:

First Year:
- Calculus I
- Calculus II
- CSCI 100: Scientific Computing

Sophomore Year:
- Linear Algebra
- Multivariate Calculus
- Transition to Advanced Mathematics

Junior Year:
- 200-level course
- 200-level course
- 300-level course

Senior Year:
- 300-level course
- Senior I.S. Semester One
- Senior I.S. Semester Two

First Year:
- Calculus II
- Multivariate Calculus
- CSCI 100: Scientific Computing

Sophomore Year:
- Linear Algebra
- Transition to Advanced Mathematics
- 200-level course

Junior Year:
- 200-level course
- 300-level course
- 300-level course

Senior Year:
- Senior I.S. Semester One
- Senior I.S. Semester Two

This sequence will help effectively develop your mathematical skills and knowledge. Since *Linear Algebra*, *Multivariate Calculus,* and *Transition to Advanced Mathematics*

provide important background for other courses, they should be completed by the end of your sophomore year. It is strongly recommended that *Transition to Advanced Mathematics* an informative precursor to any 300-level course. Additionally, students are urged to take courses that are relevant to their Senior I.S. before their senior year.

However, we recognize that the program of study for each student may vary according to individual circumstances and needs. For example, students who study off-campus for a semester will need to carefully adjust their schedule, and double majors will need to be attentive to scheduling conflicts that can arise between required courses, such as Junior I.S. It is important to follow one of these proposed schedules when possible and to discuss possible variations with your advisor.

Requirements for the Double Major

We encourage students to consider a double major. There is a synergy between the study of mathematics and of the basic concepts and principles of another discipline: each can enhance one's understanding of the other.

Students who have a strong interest in two fields should begin by discussing their interests with faculty in each department. This will help in identifying questions that can be effectively explored using the methodologies of different disciplines. To officially declare a double major you need to obtain the "Double Major Proposal" from the Dean of Curriculum's website. To complete the form you must meet with the Chair of each department to discuss potential topics for Senior I.S. Requirements for each major in a double major are the same as those for a single major with the exception that, subject to the approval of both departments/programs, a joint Senior I.S. project may be done on a topic that incorporates materials, methodologies, and approaches from both disciplines.

Students who declare a double major must complete a separate **Junior I.S.** course (401)—one in the other major department. Students who have been approved for a double major must register for the Senior Independent Study Thesis in one major during the fall semester and in the second major during the spring semester. An individualized piece of work for two departments requires some additional planning, and double major students are strongly advised to consult with both departments in mid-April of their junior year. Your mathematics advisor should help you to build a preliminary conceptual thesis that dovetails with your work in the other major.

As a double major student, your Senior I.S. thesis must satisfy the requirements of both departments. For example, most of the social and natural sciences will expect you to complete empirical research using the appropriate methods. Likewise, in the humanities, you will be expected to employ the critical methodology of the other discipline, such as literary criticism. Thus, you will learn how each discipline can

inform the work of the other. In this way, one can write a joint Senior I.S. that satisfies the criteria for both departments and yet that has the integrity of a *unified piece of work.* In addition, the Dean of Curriculum requires a "Double Major IS Agreement" to be completed by the student in conjunction with their advisors before the end of the fourth week of the fall semester. This form is available at the College's website.

Requirements for Teaching Licensure in Mathematics

Students who are planning to receive licensure in early childhood education are required to take Education 260 *Curriculum: Math/Science/Social Studies in the Early Childhood Years*. No mathematics beyond this course is required to fulfill the State requirement; however, MATH 100 would be an excellent choice to help meet Wooster's Learning Across the Disciplines requirements. Any student wishing to pursue licensure in early childhood education should plan a program carefully with the Department of Education.

For Ohio licensure in middle school or adolescent to young adult/secondary teaching of mathematics, State requirements call for at least a minor in mathematics. Because specific courses in education and mathematics are required for licensure, mathematics majors seeking licensure for teaching middle school or adolescent to young adult/secondary mathematics should plan their program early, in consultation with the Department of Education. These students may choose to write a Senior I.S. thesis on a topic related to the teaching of middle school or adolescent to young adult/secondary mathematics.

Requirements for the Minor

A minor in mathematics consists of six courses for credit, three of which must be Calculus I (111 or 108), Calculus II (112), and Linear Algebra (211). The remaining three mathematics courses must be full credit and numbered above 211. To determine which math courses would be most applicable to another discipline, students should contact a member of the department. A maximum of three courses may be transferred in to count toward a minor.

To officially declare a minor you need to obtain the "Declaration/Change of Minor" from the Dean of Curriculum's website.

IV. Off-Campus Study in Mathematics

Budapest Semesters in Mathematics:
The College has direct connections with the overseas program Budapest Semesters in Mathematics (http://www.budapestsemesters.com/). This program is designed for American and Canadian undergraduate mathematics students interested in an overseas study experience that does not hinder their progress toward a degree. Junior mathematics students with a very strong mathematics background may spend one semester in Budapest, Hungary. All courses are taught in English by Hungarians, most of which have spent some time teaching in the U.S. or Canada. Most financial aid is applicable to the program, but students with financial aid should consult directly with the Director of Financial Aid. Courses taken in Budapest appear on the student's transcript, but grades do not count toward the student's grade point average. Only courses receiving a grade of C or above will receive Wooster credit.

Math in Moscow:
http://www.mccme.ru/mathinmoscow/

MASS program at Penn State: (advanced courses in Fall semester; also has summer research opportunities)

http://www.math.psu.edu/mass/

Center for Women in Mathematics at Smith College – The Junior Program:
http://www.math.smith.edu/center/node/3

V. Senior Independent Study

Mathematics I.S. Student/Advisor Guidelines:
To meet the graduation requirements of The College of Wooster, the major in mathematics requires a two-course Independent Study Project, which culminates in an Independent Study thesis along with an oral presentation describing the thesis. The additional college requirement of one course in Independent Study is satisfied by work in courses above 212 taken to fulfill the major. This guide is intended to complement the general regulations governing Independent Study (I.S.) as articulated in the College's Handbook for Independent Study and to assist students in the planning, organization, and completion of the I.S. thesis. This guide also provides a description of what the I.S. advisor expects from the student.

I.S. is of central importance in the mathematics major and in the entire academic experience of the student. I.S. is the student's opportunity to do a significant piece of work in an area of personal interest and to expand his or her understanding of mathematics. The ability to engage in independent study is one of the primary goals of the major, and the successful completion of the I.S. thesis represents the culmination of the student's academic program. To this end we recommend that the student give serious thought to the I.S. requirement and become thoroughly familiar with the Handbook for I.S. and this guide. We reserve the right to make changes in future editions of this guide.

Project Topics:
The range of topics in mathematics is very broad. Theoretical, applied, pedagogical (for those intending to be certified to teach), and perhaps historical I.S. topics are possible. The crucial question the student must ask when evaluating a possible topic is: "Will there be a significant increase in my knowledge of some area of mathematics or in mathematics education?" The previously mentioned conversations with faculty members will be helpful in answering this question. Since I.S. constitutes two courses in the major, it is expected that about two courses worth of work in mathematics beyond that in previous courses will be done.

The topic should be chosen on the basis of the student's total academic experience and personal interests. Students are encouraged to develop projects that grow out of previous course work and related reading. Often topics, which can be only surveyed briefly in a formal course, can be expanded into an appropriate I.S. thesis. Some practical considerations that should be taken into account when choosing a topic:

1. Personal background and ability
Be sure that the topic chosen is within the range of your abilities as determined by your previous course work and reading. For instance, a student would be unwise to choose a topic in the area of Topology or probability if no formal courses have been taken in these areas. This holds true especially in application-oriented topics from specific subject matter

areas. For example, a student should not choose a mathematical modeling project in biology without demonstrable background in biology as well as the formal course in mathematical modeling.

2. Manageability and available resources
Be sure that the project is narrow enough in scope to complete within the time allotted for the I.S. thesis. A student should be certain that there exists a sufficient bibliography to support the project. Necessary materials that are not among the holdings of the Andrews Library can usually be acquired through other Library services, although a considerable time lag might be involved. Therefore, students should use existing resources available on campus as much as possible.

3. Limitations.

- The project must expand the student's knowledge and demonstrate a synthesis of information on a topic from many sources.
- There must be resources available, or which can be readily acquired, for the project.
- The student must have the appropriate mathematical background for the project.
- A faculty member must agree to supervise the project.
- Working selected problems from a single textbook on any topic will not constitute an acceptable I.S. project.
- The history of an area of mathematics is not acceptable in and of itself unless it encompasses the learning of a significant body of mathematics.
- Although the faculty advisor must approve all topics, the student is free to pursue virtually any area of mathematics that is of interest. Some suggested topics include Abstract Algebra, Number Theory, Partition Theory, Combinatorics, Graph Theory, Matrix Theory, Operations Research (Deterministic and Stochastic), Mathematical Programming (Linear, Nonlinear, Integer, Dynamic), Management Science, Topology, and Algebraic Topology.

Project Submissions:

Project Proposal
The project abstract is a formal document, not a slip of paper with a few vague ideas on it about what the student thinks would be interesting to do. In order to receive approval for a project, the student will present a proposal outlining the following:

- The project's focus (e.g., examine the Riemann Hypothesis, study Queuing Theory, examine the Axiom of Choice).
- The project's objectives in terms of the topics that the I.S. thesis will cover and the learning that will result from accomplishing the project;
- The efforts that will contribute to the project: programming, interviews, special library research, trips, and needed materials (books, software, documentation, etc.).

- Potential problems in the project that might become trouble spots. Identify the challenges the student might encounter in accomplishing the project. The student should investigate whether these trouble spots could make the rest of the project impossible if they can't be surmounted.
- A suggested timetable specifying the points throughout the two semesters at which the various phases of the project will be complete.
- A minimum of five references (journal articles, technical reports, books) on your proposed topic. Online references are not, generally, acceptable.

Project Research
The project should begin with a substantial amount of library research. The description of this research should involve a clear exposition of the problem or research area, an annotated bibliography, and an outline for conducting the research.

Annotated Bibliography
An annotated bibliography is a bibliography in which each entry includes a description of the entry's content and the role it might take in the research. This description is not a copy of the entry's abstract. For example:

Taalman, Laura. "Taking Sudoku Seriously." Math Horizons. September 2007, 5-7.
The author gives an overview to the Sudoku puzzle, including the rules and counting the number of possible Sudoku boards. It is an introductory article complete with concise terminology to use, mention of results about Sudoku and remaining open questions are included. Many of the primary resources in the article should be investigated and evaluated.

Thesis Outline
This will include a proposed table of contents (or outline) for the thesis. The table of contents should include a title and a specification of chapters and sub-sections.

Completed Chapters
In mid-October, the student will reach an agreement with his/her advisor about a comprehensive narrative to be completed as a prerequisite to satisfactory completion of the first semester of Senior I.S. This comprehensive narrative must be submitted by the date given on the timeline later in this document. The comprehensive narrative is not an outline or a draft, but a significant written portion of the I.S. that has been through at least one review by the advisor.

A full final draft will be submitted to the advisor in the second semester of the Senior I.S. project.

Digitial I.S. Document

It is required that students submit online to the Registrar a digital copy of your Senior I.S. project for the Digital I.S. Repository.

Poster
This document represents the I.S. in poster form and will be presented during the Senior I.S. celebration day in April. It can be a traditional or digital in nature and students should consult their advisor about the format of their poster.

Document Submission and oral presentation schedule
The student will meet with the advisor once a week to discuss ideas relating to the project, review progress, and map out work to be done. In December, all Mathematics I.S. students will meet as a group to give a brief presentation of their work and progress to that point (dates are below).

With the exception of the oral defense, the student will submit a typed document for each item by 4:00 PM on the indicated day. The student will submit the final thesis to the Registrar's office on the indicated day; all other documents will go to the advisor. Advisors will not discuss assignments with students on the day they are due or the day before. The schedule of submission is as follows:

Junior Year, Second Semester

Friday of last week of classes - IS Preliminary Proposal
Proposal form needs to be submitted to Department Chair.

Senior Year, First Semester

Friday of 3rd week - Topic and Annotated bibliography
An annotated bibliography is a list of citations to books, articles, and documents. Each citation is followed by a brief (usually about 150 words) descriptive and evaluative paragraph, the annotation. The purpose of the annotation is to inform the reader of the relevance, accuracy, and quality of the sources cited. Below is an example of one such citation that would appear:

Taalman, Laura. "Taking Sudoku Seriously." Math Horizons. September 2007, 5-7. The author gives an overview to the Sudoku puzzle, including the rules and counting the number of possible Sudoku boards. It is an introductory article complete with concise terminology to use, mention of results about Sudoku and remaining open questions are included. Many of the primary resources in the article should be investigated and evaluated.

Friday of 6th week - Project Proposal - Description/Goals
This is a one-page description of what your project will be about.

Friday of 12th week - A Comprehensive Narrative
This could be a background exposition, a history chapter describing the general area of research, a literature review, or it may be a later chapter of the thesis. In any case, it should be a substantial written portion of the thesis.

Friday after Thanksgiving Break - Outline
This should be a detailed outline of the thesis.

Tuesday of last week of classes - Oral presentation
This should be a five-seven minute presentation on your project and progress in the first semester. Your presentation should make use of some form of presentation software.

Grading, Fall Semester:
Below are the components that will determine your IS grade for MATH 451 (usually completed in the fall semester of the Senior year). The due dates given earlier are suggestions and you will determine and record the actual due dates in consultation with your advisor. Each component is worth approximately 20% of your overall grade for MATH 451. Your grade on each component will reflect your promptness, clarity of presentation, thoroughness, and consistency with documents already submitted. To obtain a satisfactory progress (SP) grade in MATH 451, the student must complete all indicated submissions and receive at least an 81%. The table below suggests a 100-point scale but it is within the purview of the advisor to determine how they will measure successful progress and to communicate this to the student.

Project proposal and outline	_____	20 points
Oral presentation	_____	20 points
Subject and annotated bibliography	_____	20 points
Comprehensive narrative	_____	20 points
Attendance	_____	20 points

Grade for first semester:
SP: 81 to 100 points
NC: 0 to 80 points

Senior Year, Second semester

Tuesday of 1st week - IS Student meeting
A meeting to remind students of formatting requirements and to answer any questions they may have.

Friday of 1st week - Table of Contents and Second chapter
A Table of Contents that should be close to the final product and another substantial written portion of the IS.

Friday of 7th week - First complete draft
Changes beyond this copy should only be editorial and only a minimum of new material should be written. See the IS Guidelines for formatting information.

First Monday after Spring Break - Final thesis

Oral
TBD

Grading, Spring Semester:
The spring semester grade (H, G, S, NC) will largely represent an evaluation of the final thesis, the oral presentation, and the organization of the project effort. The following criteria determine the final grade. You should also look at the attached evaluation rubrics for the IS thesis and oral presentation.

CONTENT:
The content of the independent study document must meet the requirements agreed upon by the IS advisor and advisee. These requirements will differ for each project.

FORM:

The final independent study document is evaluated for mechanical and grammatical errors. The text must be well organized, grammatically correct, and complete - including a table of contents, an introductory and conclusion chapter, a bibliography, and a user manual if necessary.

Formatting

Overall Document
Left margin 1.5 in
Right margin 1.25 in
Top margin 1 in
Bottom margin 1 in
Pages should also be numbered
Double-sided and Spiral bound
Chapters start on a new page
Theorems, lemmas, examples, corollaries, definitions, propositions, remarks, notation, terminology, figures, and tables numbered within Chapters.

Title page (no page number - everything centered except Advisors which are on left margin)
Title
Independent Study Thesis
Presented in Partial Fulfillment of the Requirements for the Degree Bachelor of Arts in the Department of Mathematics and Computer Science at the College of Wooster
by
Author
The College of Wooster
Year
Advised by:
Advisors

Frontmatter (Page numbers at bottom of pages)
Blank page hidden page number
Copyright page (optional and hidden page number)
Abstract (roman page number (ii or iii based on copyright or not))
Dedication (optional)
Acknowledgments (optional)
Vita (optional)
Table of Contents
List of Figures (only needed if there are figures)
List of Tables (only needed if there are tables)
List of Listings (only needed if there are code listings)
Preface (optional) (A chapter which is not numbered or lettered)

Mainmatter
Numbered Sections (Page numbers in arabic, first page number of chapter centered at bottom, remaining page numbers in upper right and running header on upper left (Chapter number Chapter title))
Introduction (Chapter 1)
Body (Chapters 2-?)

Backmatter
Lettered Sections (Page numbers in arabic, first page number of appendix centered at bottom, remaining page numbers in upper right and running header on upper left (Appendix letter Appendix title))
Appendices

Sections not lettered or numbered
Afterword (optional)
References
Index (optional) (two column alphabetized)
Colophon (optional)
Blank page (hidden page number)

An example of a completed thesis can be seen in the LaTeX IS Guide found at:
https://wiki.wooster.edu/display/latex/Downloads

> METHODOLOGY:
> The essential factor here is the degree to which the student has approached the project in an organized and efficient manner and has applied effort consistently throughout the entire year. The quality and promptness of intermediate submissions is highly important. A major item is the promptness and quality of the rough draft submission since it measures the ability of the student to effectively coordinate the research effort in an efficient manner. Attendance and presentation issues from the first semester will carry a heavy weight for this criterion.
>
> ORAL PRESENTATION:
> Grading of the oral presentation evaluates the organization, spontaneity, flow, continuity, and comprehensibility of the presentation. It also evaluates the student's ability to respond to reasonable questions and explain points of confusion. The student should use visual aids as a means of guiding the presentation, but should avoid reading material to the audience. The presentation should last approximately thirty-five minutes to permit approximately fifteen minutes for questions and extended discussion. A major challenge of the presentation is to identify the key points to cover in giving a good description of the project in a relatively short time period.

VI. Independent Study Assessment Guide

Math 452 Evaluation Rubric (revised fall 2012)

This rubric serves as a starting point for discussion among the mathematics faculty about Math 452 grades. Not all questions apply equally well to every project, and some are only appropriate for the first reader. Roughly speaking, a score of 4 in an area corresponds to Honors-level achievement, 3 to Good, and 2 to Satisfactory, with 1 and 0 indicating substandard performance. However, the way in which these elements are weighted is topic-dependent, and a particular set of scores does not guarantee a certain 452 grade. For double majors, the evaluation of the project from the perspective of the other discipline is also significant in determining the grade.

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1. **Extent of Material Covered** – Based on the material covered in the final written document and (for first readers only) your weekly meetings with the student, which statement best describes the extent of the student's investigation? (Use 1a for all projects, and also 1b if it applies.)

1a. **Extent of Investigation** – Which statement best describes the extent of the student's investigation?

- **(4 - Exceptional)** The student did a thorough investigation into a focused topic, providing examples and going well beyond the minimum extent required of a two-semester project.
- **(3 - Strong)** The student did a comprehensive summary of a focused topic, providing examples and personalizing the material.
- **(2 - Adequate)** The student did a good summary of material pertaining to a defined topic, and the extent is sufficient for a two-semester investigation.
- **(1 - Marginal)** The student covered some portions well, but failed to go far enough with others, and/or lacked a topical focus.
- **(0 - Unsatisfactory)** The student provided a brief summary of the material, but the extent was insufficient for a two-semester investigation and/or the content was so widely scattered as to make the central topic unclear.

1b. **Extent of Application** – If applicable, which statement best describes the student's mathematical modeling?

- **(4 - Exceptional)** The student has a thorough understanding of the application area, which is reflected with originality in an innovative model.
- **(3 - Strong)** The student has a thorough understanding of the application area, and all key aspects are reflected in the model.
- **(2 - Adequate)** The student has an understanding of the application area, with some key aspects reflected in the model.
- **(1 - Marginal)** The student has a weak understanding of the application area, resulting in a deficient model.
- **(0 - Unsatisfactory)** The student has a clear lack of understanding of the application area, resulting in a poorly-designed model.

2. Appropriate Use of Resources (Use one or both parts, based on their applicability to the student's project.)

2a. **Use of Prior Literature** – Allowing for differences based on mathematical subfields and the topic of the student's investigation, which statement best describes the use of related prior literature in the thesis?

- **(4 - Exceptional)** The student used appropriate resources, integrated them into one coherent narrative, and understands the place of their own work in the context of the wider subfield of mathematics.
- **(3 - Strong)** The student successfully used appropriate resources, and some integration is apparent in the thesis.
- **(2 - Adequate)** The student successfully used appropriate resources.
- **(1 - Marginal)** The student's use of resources is somewhat inadequate.
- **(0 - Unsatisfactory)** The student's use of resources is substantially inadequate, significantly impacting the quality of the thesis.

2b. **Use of Computational Tools** – Which statement best describes the student's use and justification of computational methods used in this investigation?

- **(4 - Exceptional)** The student successfully used appropriate computational tools, and fully justified them (through literature review and/or preliminary investigation).
- **(3 - Strong)** The student successfully used appropriate computational tools, and mostly justified their use.
- **(2 - Adequate)** The student successfully used appropriate computational tools, but the justification is weak.
- **(1 - Marginal)** The student used inappropriate computational tools, did not justify their selection, and/or was only partially successful in using them.
- **(0 - Unsatisfactory)** The student was unsuccessful in using computational tools.

3. **Writing Quality** – Which statement best describes the quality of the student's writing in the thesis, including organization, readability, mathematical precision, form (grammar, spelling, typesetting), and style?

- **(4 - Exceptional)** The I.S. is written in a clear, precise well-organized manner, with excellent form. Moreover, it is written in the student's unique style and directed toward an audience of peers.
- **(3 - Strong)** The I.S. is well-organized and very readable, with only minimal errors in any of these areas.
- **(2 - Adequate)** The I.S. is well-organized and readable, despite some lack of precision and/or errors in form.
- **(1 - Marginal)** The I.S. is somewhat difficult to read, because of weak organization and/or significant issues in form or precision.
- **(0 - Unsatisfactory)** The I.S. is quite difficult to read, because of disorganization and/or pervasive issues in one or more of these areas.

4. **Presentation** – Which statement best describes the quality of the student's final oral presentation, considering organization, knowledge of content, audience awareness, and professionalism? (For double majors whose oral exam begins from a poster, rather than an oral presentation, consider the poster instead.)

- **(4 - Exceptional)** The presentation was excellent overall, and strong in each of these aspects.
- **(3 - Strong)** The presentation was solid, with only minimal problems in any of these aspects.
- **(2 - Adequate)** The presentation was acceptable, despite some weakness in one or more aspects.
- **(1 - Marginal)** The presentation was substantially hampered by a pronounced weakness in at least one aspect.
- **(0 - Unsatisfactory)** The presentation was unacceptable, with pronounced weaknesses in multiple aspects.

5. **Independence of Learning** (for first readers only) – Based on the weekly meetings with your I.S. student, which statement best describes the student's initiative and independence throughout the process?

- **(4 - Exceptional)** The student demonstrated strong initiative and independence, requiring only a minimal amount of guidance.
- **(3 - Strong)** The student demonstrated good initiative and worked mostly independently, requiring an appropriate amount of guidance.
- **(2 - Adequate)** The student was self-directed for some of the thesis, but required lots of guidance on other parts.
- **(1 - Marginal)** The student was unable to work without strict deadlines and lots of guidance regarding the direction of the thesis.
- **(0 - Unsatisfactory)** Despite deadlines and guidance from the advisor, the student failed to complete work in a timely manner.

6. **Student Understanding and Mastery of the Subject** – Based on the written thesis, the oral examination, and (for first readers only) weekly meetings, which statement best describes this student's understanding of the content in the I.S.?

- **(4 - Exceptional)** The student has a thorough understanding of the material and was able to answer nearly all probing questions.
- **(3 - Strong)** The student has a good understanding of the material was able to answer questions in all areas of content, including some probing questions.
- **(2 - Adequate)** The student has a good understanding of most of the material, but had difficulty answering probing questions.
- **(1 - Marginal)** The student lacks understanding of significant portions of the material, and had difficulty answering most questions.
- **(0 - Unsatisfactory)** The student lacks a basic understanding of the material and was unable to answer basic questions.

VII. Further Learning Opportunities

At Wooster

Mathematics Colloquia

Throughout the year, mathematicians are invited to campus to give talks. These are valuable opportunities to be exposed to different mathematical ideas and to engage mathematicians outside of Wooster faculty.

Math Table

Roundtable is held every week, usually in Lowry dining hall. All majors, faculty, and friends are invited to attend.

Student Mathematical Association of America Chapter (SMAAC)

Students are encouraged to join Math Club. The organization plans social activities and an annual high school mathematics competition. Each year, 'Taylor Bowl' pits the Mathematics and Physics departments against one another in bowling at Scot Lanes.

Putnam Exam

The William Lowell Putnam Mathematical Competition, often abbreviated to the Putnam Exam, is an annual mathematics competition for undergraduate college students of the United States and Canada, awarding scholarships and cash prizes ranging from $250 to $2,500 for the top students and $5,000 to $25,000 for the top schools. Elizabeth Lowell Putnam founded the competition in 1927 in memory of her husband William Lowell Putnam, who was an advocate of intercollegiate intellectual competition. The exam has been offered annually since 1938 and is administered by the Mathematical Association of America.

COMAP Mathematical Contest in Modeling (MCM)

Mathematical Contest in Modeling (MCM), challenges teams of students to clarify, analyze, and propose solutions to open-ended problems. The contest attracts diverse students and faculty advisors from over 500 institutions around the world each February.

Teaching Apprenticeships

The department offers students the opportunity to serve as a teaching apprentice for some courses. The goal of this course is to help students reflect upon the nature and process of teaching and education and to also gain a deeper understanding of the course's subject matter. If there is an area of mathematics in which you are especially interested and you would like to assist in the teaching process, please approach the professor as early as possible.

The Math Center Tutoring and Grading

The Math Center staff assists students with understanding of concepts, examples, and homework problems. Each semester there are tutor openings for students and availability for students to grade homework assignments for faculty.

Sophomore Research/HHMI

Faculty are engaged in research projects, and the department itself sometimes has research needs. If you are interested in participating in the Sophomore Research Program, please ask members of the department. Information about the College's support for undergraduate research is available on the College website.

Applied Mathematical Research Experience (AMRE)

The Applied Mathematical Research Experience (AMRE) is a program initiated by the Department of Mathematics and Computer Science designed to give students from The College of Wooster experience in the practical applications of mathematics and computer science that the classroom cannot provide. For eight weeks of the summer, student teams and faculty advisors from the College of Wooster are joined with a (usually local) business, industry, or agency (client).

The structure of the program is based upon several research teams that work independently on separate projects, but also come together for discussion of progress. These teams are comprised of students (usually three) and a faculty advisor. The faculty advisor involvement is heavy initially as the student team becomes familiar with the project definition. After approximately two weeks, involvement becomes primarily advisory as the students work directly with client representatives and others. Student teams give weekly progress reports in the form of oral presentations, in addition to periodic presentations to their respective clients. Each team also gives a final oral presentation and written report to the client upon completion of the project.

In addition to work done on the project, a number of lectures are a part of the AMRE program. These lectures are intended to teach the students skills or tools necessary to complete their assigned projects. Colloquia are also given on a variety of topics including group dynamics and oral presentation. These presentations are given by individuals from academia, local corporations and professional consultants.

Applications are accepted each February and positions are open to all College of Wooster students.

Beyond Wooster

Summer Programs in Mathematics

Program	*Website*
REU (Research Experiences for Undergraduates) *NSF-funded programs are open only to US citizens and permanent residents*	http://www.nsf.gov/crssprgm/reu/ (Click on \Search for an REU Site" and then on \Mathematical Sciences.")
Further undergraduate opportunities	http://www.ams.org/employment/undergrad.html
Links to summer research programs and internships, as well as other information such as graduate school advice.	http://www.maa.org/students/undergrad/
For an informal description and discussion of REUs	http://www.maa.org/students/undergrad/research.html See the link "Is an REU for You?"
SIAM student website for lists that include a variety of opportunities, often in applied mathematics:	http://www.siam.org/students/resources/fellowship.php
Miami University of Ohio – SUMSRI	http://www.units.muohio.edu/sumsri/
Summer Math Institute (SMI) at Cornell University	http://www.math.cornell.edu/~smi/
Wabash College – Wabash Summer Institute in Mathematics (WSIM)	http://www.wabash.edu/academics/math/wsim

Summer Programs for Women in Mathematics:

Program	*Website*
Carleton College – Summer Mathematics Program for Women (SMP)	http://www.math.carleton.edu/smp/
George Washington University – Summer Program for Women in Mathematics (SPWM)	http://www.gwu.edu/~spwm/

Summer Programs that do not require US citizenship:

Program	*Website*
SMALL Undergraduate Research Project at Williams College	http://math.williams.edu/small/
Park City Math Institute – Institute for Advanced Study	http://pcmi.ias.edu/program-ugss/
Research in Industrial Projects for Students (RIPS) at UCLA	http://www.ipam.ucla.edu/programs/rips2010/
Mathematical Biosciences Institute at The Ohio State University	http://mbi.osu.edu/eduprograms/undergrad2010.html

Summer Internships:

Summer Experience	*Website*
For math-related jobs at companies from Amazon.com to Xerox	http://www.ams.org/employment/internships.html
Searchable database of science and math internships for undergraduates	http://www.jyi.org/SCC/internships.php
Statistics internships for undergraduates	http://www.amstat.org/education/internships.cfm

Summer Teaching:
(Note: Most of those websites are aimed at prospective students, not counselor/tutors. You will usually have to contact individual programs to apply to be a counselor.)

Program	*Website*
The PROMYS program at Boston University hires undergraduates as counselors for an intensive math camp for bright high school students.	http://www.promys.org/
Center for Talented Youth (Johns Hopkins University)	http://www.cty.jhu.edu/
Other similar programs exist all around the county. For a longer list, see the AMS	http://www.ams.org/employment/mathcamps.html

VIII. Departmental Honors and Prizes

The Foster Prize in Mathematics was established in 2001 with gifts from Walter D. Foster and Richard S. Foster '71. Income from the fund is awarded annually to the senior mathematics major who has demonstrated the most improvement in mathematics during his or her college years, as judged by the Mathematics Department faculty.

The Lyman C. Knight, Sr. Prize in Physical Education and Mathematics was established in 1978 and honors Professor Knight's thirty years of service from 1910 to 1940 as a member of the Department of Mathematics. It is awarded to a sophomore who has demonstrated both outstanding promise in high school and first-year mathematics and has superior physical skills.

The Elizabeth Sidwell Wagner Prize in Mathematics, established in 1966 by Dr. and Mrs. Cary R. Wagner, is awarded annually at the beginning of the senior year to that student who showed the greatest aptitude during the junior year and, in the opinion of a jury, seems most likely to succeed in mathematics.

The William H. Wilson Prize in Mathematics was established in 1926 in memory of William H. Wilson, of the class of 1889, professor of mathematics in the College from 1900 to 1907. The prize is awarded annually to that member of the senior class who has shown the greatest proficiency in mathematics.

X. Mathematics After Wooster

Selected Mathematical Careers

Organization	*Website*
American Mathematical Society (AMS)	www.ams.org
Mathematical Association of America (MAA)	www.maa.org
Society for Industrial and Applied Mathematics (SIAM)	www.siam.org
National Security Agency (NSA)	www.nsa.gov
Society of Actuaries (SOA)	www.soa.org
U.S. Bureau of Labor Statistics (BLS)	www.bls.gov
The Society for Mathematical Biology (SMB)	www.smb.org
Mathematical Sciences Research Institute (MSRI)	www.msri.org

The College of Wooster also has a Career Services office in APEX. The mission of Career Services office is to help students bridge their liberal arts education with their career journey. They offer a comprehensive range of services, including individual career advising and group programs, assisting students in understanding their skills, interests, and values while connecting this knowledge with various career options.