2019-2020

Name: _____

Advisor: _____

Email: _____

Undergraduate Advising Manual

Fall 2019 – Spring 2020

(updated July 2021)

100 Whitehead Hall
The Johns Hopkins University
http://engineering.jhu.edu/ams/
410-516-7195

"It is important for him who wants to discover not to confine himself to one chapter of science, but to keep in touch with various others."

--- Jacques Hadamard

1 INTRODUCTION

The teaching and research programs of the Department of Applied Mathematics and Statistics span modern applied mathematics. The department's curriculum in Probability/Statistics covers probability theory, stochastic processes, and applied and theoretical statistics. Its Operations Research/Optimization curriculum includes continuous and discrete optimization, numerical optimization, network models, computer modeling, and game theory. Its curriculum in Discrete Mathematics includes combinatorics, graph theory, and cryptology and coding; and its curriculum in Scientific Computing includes computing, numerical analysis, matrix analysis, and mathematical modeling. Its curriculum in Financial Mathematics includes fundamental courses in investment science, financial derivatives, optimal portfolios, risk management and hedging. The programs of the department emphasize mathematical reasoning, mathematical modeling and computations, abstraction from the particular, innovative application of mathematics, and development of new methodology.

The current University Catalog contains a detailed description of the department's courses, programs, and requirements and a list of the current faculty and their interests. The purpose of this brochure is to present supplemental information; it should be read along with the departmental listing in the Catalog. (In particular, the course offerings of this and other departments change over the years, so some of the courses listed in sections 5 and 6 may no longer be offered or have different distribution codes; see the current course list for the latest offerings.)

2 DEGREE PROGRAMS

According to his or her interests, an undergraduate major in Applied Mathematics and Statistics can earn either the B.A. or the B.S. degree, by meeting the general university requirements, the general requirements of the School of Engineering (based on B.A. or B.S.), and the departmental requirements. Beginning with a core of basic work in general mathematics, probability, statistics, optimization, discrete mathematics, and scientific computing, the student can construct a program to prepare for his or her particular career objectives.

The department's graduate program leads to the M.A., M.S.E., and Ph.D. degrees. There is also a combined bachelor's/master's program under which exceptionally able undergraduates may be admitted early to concurrent graduate work.

The department also offers a Minor in Applied Mathematics and Statistics which is open to undergraduate students majoring in any department of the School of Engineering or the School of Arts and Sciences.

3 BACHELOR'S PROGRAMS

The requirements for the major are very flexible, but each student should have a definite plan for his or her academic program. With the advice and consent of the faculty advisor, each student constructs an

individual program satisfying the requirements below. A written copy of this program should always be on file with the faculty advisor, although it may need to be revised and updated from time to time. See also the advice at the end of Section 10 concerning maintenance of a portfolio of work.

Courses are classified as one or more of the types "E" (engineering), "H" (humanities), "N" (basic science), "Q" (quantitative studies), "S" (social and behavioral sciences), and "W" (writing-intensive). The codes E, H, N, Q, S, and W are indicators as to whether a course is suitable to help meet distribution requirements.

3.1 Minimum Degree Requirements

For either degree (B.A. or B.S.), there is a minimum degree requirement of 120 credits. The student's advisor must approve all course selections. Every department major for the B.A. or B.S. degree must meet the following departmental requirements.

All courses used to meet the following departmental requirements must be taken for a letter grade and passed with grade of C- or higher:

1. Calculus I, II, and III: The courses 110.106-107 or 110.108-109 or 110.113 can be used to satisfy the Calculus I and II requirements. The courses 110.202 or 110.211 satisfy the Calculus III requirements. Advanced placement is acceptable as well.
2. Two courses in linear algebra and differential equations. These two courses must, collectively, touch both areas. There are two ways to meet this two-course requirement:
    a. 110.201 or 110.212 for linear algebra, and 110.302, 110.306, 110.417, 553.386, 553.388, or 553.391 for differential equations; or
    b. 553.291 for an introduction to both linear algebra and differential equations, and an additional course in linear algebra or differential equations chosen from among the following: 553.385, 553.386, 553.388, 553.391, 553.792, and 110.417.
3. Two courses in numerical/scientific computing (one Basic and one Advanced):
    a. Basic: JHU credit for AP Computer Science, 500.112, 500.113, 500.114, 250.205, 530.371, 540.305, 560.220, 580.200, 601.220, or 580.242 AND 580.244.
    b. Advanced: 110.445, 553.281, 553.383, 553.385, 553.386, 553.388, 553.400, 553.413, 553.433, 553.436, 553.443, 553.450, 553.481, 553.488, 553.493, 601.433, 601.475, 601.482 or one of the courses approved to meet the AMS Master's/PhD computing requirement.
4. A course in discrete mathematics: 553.171, 553.172, 553.371, 553.471, or 553.472 is acceptable.
5. Two upper-level courses in Probability and Statistics: 553.420, and either 553.430 or 553.431.
6. An upper-level course in optimization: 553.361.
7. Completion of an area of focus, chosen from the list below. Two additional courses are to be taken in the area of focus, distinct from those used to satisfy requirements 5 and 6.
    a. Probability and Stochastic Processes: 110.445, 553.426, 553.427, 553.433, 553.492, 110.405
    b. Statistics and Statistical Learning: 110.445, 553.400, 553.413, 553.414, 553.416, 553.417, 553.433, 553.436, 553.439, 553.450
    c. Scientific Computing: 110.445, 553.383, 553.385, 553.386, 553.388, 553.433, 553.481 with neither the pair 553.385-553.386 nor 553.386-553.388 allowed in fulfillment of the area of focus
    d. Optimization and Operations Research: 553.362, 553.400, 553.453, 553.463, 553.465, 553.467
    e. Discrete Mathematics: 553.371, 553.463, 553.471, 553.472, 110.401
    f. Financial Mathematics: 553.427, 553.441, 553.442, 553.444, 553.445, 553.447, 553.448, 553.449, 553.488
8. Courses coded (Q) totaling 40 credits, of which at least 18 credits must be in courses numbered 300 or higher. (Courses used to meet the requirements above may be counted toward this total.)
9. For the B.S. degree, at least 12 credits coded (N). Laboratory courses that accompany (N) courses

may be used in reaching this total. (Courses used to meet the requirements above may be counted toward this total.) Intersession courses only graded on an S/U basis may also be used toward this requirement when passed with an S.

In addition to satisfying departmental requirements, candidates for a B.A. or B.S. degree must fulfill the general requirements of the School of Engineering, and the general university requirements. Please see the course catalog (http://web.jhu.edu/registrar/catalog) for the B.A. and B.S. requirements. The codes E, Q, H, N, S, and W are indicators as to whether a course is suitable to help meet distribution requirements.

3.3 Honors

The Department of Applied Mathematics and Statistics awards departmental honors based on a number of factors, including performance in coursework, research experiences, teaching, and service.

If a student completes a senior thesis (553.501) and also earns a GPA of 3.5 or higher in Applied Mathematics and Statistics courses, then the student will automatically be awarded departmental honors.

3.4 Computing

The importance of computing in modern applied mathematics and statistics can hardly be overstated. Students majoring in Applied Mathematics and Statistics will benefit greatly by learning about the design, analysis, and implementation of numerical methods and algorithms, and symbolic methods, used to solve problems in mathematics and statistics. Departmental majors are strongly advised to learn to program (for example, in the programming language MATLAB), and specifically to fulfill the computing requirement (requirement 3 listed in Section 3.1), as early as possible in their programs of study. In addition to being important for career development, it is also extremely helpful in upper-level courses for students to have a strong computing background.

3.5 Remarks

It is highly recommended that students take additional departmental courses, in order to establish a broad foundation for a career as an applied mathematician. Of particular importance are additional courses in optimization (553.362), stochastic processes (553.426), statistics (553.413, 553.432, 553.433, 553.434), dynamical systems (553.391), mathematical modeling and consulting (553.400), scientific computing (553.385, 553.386) and investment science (553.442). Students planning to continue to graduate school in an applied mathematics program are encouraged to consider taking one or more graduate-level courses in probability (553.720, 553.721), statistics (553.730, 553.731), optimization (553.761, 553.762), combinatorics (553.671), graph theory (553.672), numerical analysis (553.781), and matrix analysis (553.792).

The department also encourages its majors who plan to enroll in a graduate program in mathematics to obtain at least a reading knowledge of French, German, or Russian.

For information on the combined bachelor’s-master's program, see Section 8 below.

APPLIED MATHEMATICS AND STATISTICS
DEPARTMENTAL MAJOR REQUIREMENTS CHECKLIST 2019-2020
(TWO PAGES)

All courses used to meet major requirements must be taken for a letter grade and passed with a C- or higher.

Forty (40) Q credits (of which 18 must be at the 300-level or higher) are required for the AMS major.

Courses coded Q listed below count toward this total.

AMS Core Requirements	**Course(s) Taken for Requirement**	**Semester and Year Taken**
Calculus I (110.106 or 110.108)		
Calculus II (110.107, 110.109, or 110.113)		
Calculus III (110.202 or 110.211)		
Linear Algebra and Differential Equations (a) (110.201 or 110.212) and (110.302, 110.306, 110.417, 553.386, 553.388, or 553.391) OR (b) 553.291 and (553.385, 553.386, 553.388, 553.391, 553.792, or 110.417)		
Scientific Computing **One Basic Course AND One Advanced Course** (**Basic**: JHU credit for AP Computer Science, 500.112, 500.113, 500.114, 250.205, 530.371, 540.305, 560.220, 580.200, 601.220, or 580.242 AND 580.244) (**Advanced**: 110.445, 553.281, 553.383, 553.385, 553.386, 553.388, 553.400, 553.413, 553.433, 553.436, 553.443, 553.450, 553.481, 553.488, 553.493, 601.433, 601.475, 601.482)		
Discrete Mathematics (553.171, 553.172, 553.371, 553.471, or 553.472)		
Probability and Statistics (553.420 and either 553.430 or 553.431)		
Optimization 553.361		

AMS Area of Focus Requirement

Students must also complete an area of focus within applied mathematics and statistics from among those listed below, by taking two additional courses in the area of focus. These courses must be distinct from those used to satisfy the core requirements of probability and statistics, and optimization.

AMS Area of Focus Requirements	Courses Taken for Requirement	Semester(s) and Year(s) Taken
Discrete Mathematics (553.371, 553.463, 553.471, 553.472, 110.401)		
Financial Mathematics (553.427, 553.441, 553.442, 553.444, 553.445, 553.447, 553.448, 553.449, 553.488)		
Optimization and Operations Research (553.362, 553.400, 553.453, 553.463, 553.465, 553.467)		
Probability and Stochastic Processes (553.426, 553.427, 553.433, 553.492, 110.405, 110.445)		
Scientific Computation (110.445, 553.383, 553.385, 553.386, 553.388, 553.433, 553.481) (Neither the pair 553.385-553.386 nor 553.386-553.388 are allowed in fulfillment of the area of focus.)		
Statistics and Statistical Learning (110.445, 553.400, 553.413, 553.414, 553.416, 553.417, 553.433, 553.436, 553.439, 553.450)		

In addition to requirements for the departmental major, all students must complete JHU General Requirements. See the JHU Catalog or the Appendix of this manual for JHU General Requirements for Departmental Majors (distribution requirements) which are required of all undergraduates and differ based on the degree sought (B.A. or B.S.)

4 MINOR IN APPLIED MATHEMATICS AND STATISTICS

The minor in Applied Mathematics and Statistics should be attractive to students majoring in a variety of disciplines, both in the School of Engineering and in the School of Arts and Sciences. The minor provides formal recognition of depth and strength of a student's quantitative knowledge beyond the minimal requirements of his/her major.

The requirements of the minor in Applied Mathematics and Statistics are the following:

1. Completion of an approved program of study containing at least 18 credits in courses coded Q. The first two courses in calculus (110.106-107 or 110.108-109 or 110.113 or their equivalents) may not be used to fulfill this requirement.

2. Among the courses comprising the 18 credits, there must be:

   (a) at least four courses in the Department of Applied Mathematics and Statistics (each of these must be a 3- or 4- credit course);
   (b) at least three 3- or 4- credit courses at the 300-level or above, of which at least two must be in the Department of Applied Mathematics and Statistics;
   (c) an approved semester course based on a high-level computer language (171.426, 250.205, 500.200, 510.202, 530.371, 540.305, 553.281, 553.383, 553.385, 553.386, 553.388, 553.400, 553.413, 553.433, 553.436, 553.443, 553.450, 553.487, 553.488, 553.489, 553.493, 560.220, 570.210, 580.200, 580.223, 601.475, 601.482 or one of the courses approved to meet the AMS Master's/PhD computing requirement.)

3. The grade in each course counted in fulfillment of requirements for the minor must be at least C-. All courses must be taken for a letter grade.

4. Students may not count all 3 courses, 553.310/311, 553.420 and 553.430 toward minor requirements.

A student wishing to complete a minor in Applied Mathematics and Statistics should complete a Program Proposal form, which is available online at http://engineering.jhu.edu/ams/undergraduate-studies/undergraduate-program-overview/minor-requirements/, and submit the proposal to the Applied Mathematics and Statistics Department (100 Whitehead Hall) for approval by the Academic Program Coordinator.

5 PLANNING YOUR COURSE PROGRAM

The Department's major requirements allow considerable flexibility in planning a course program to suit the interests of the student. The following guidelines and suggestions are provided to help students structure their thinking about the program. A student's actual program should be planned in consultation with the faculty advisor.

The Freshman and Sophomore Years

Certain courses should be taken during the freshman and sophomore years, to provide a solid preparation for advanced courses during the junior and senior years. Unless explicitly noted, all courses in the following list are offered in both fall and spring semesters, so the list may be rearranged to meet the student's needs.

Freshman Year – Fall Semester
- 110.108 Calculus I
- 550.171 Discrete Mathematics

Freshman Year – Spring Semester
- 110.109 Calculus II

Sophomore Year – Fall Semester
- 110.202 Calculus III
- An approved computing course (see requirement 3 in section 3.1 and section 3.5)

Sophomore Year – Spring Semester
- 110.201* Linear Algebra or 110.212* Honors Linear Algebra or 553.291* Linear Algebra and Differential Equations

* Students should consult the department's linear algebra and differential equations requirement (see requirement 2 in section 3.1) for additional details.

Many freshmen will have already completed Calculus I or II during high school, and may start at a higher level in the fall semester of the freshman year. Students who finish Calculus II during the freshman year are encouraged to take 553.420 Introduction to Probability during the fall semester of the sophomore year and 553.430 Introduction to Statistics during spring semester of the sophomore year. Students who finish Calculus II during the fall semester of the freshman year are strongly advised to take an approved computing course during the spring semester of the freshman year.

6 COURSES IN OTHER DEPARTMENTS

The following courses have been recommended by Applied Mathematics and Statistics undergraduates as being useful and/or interesting:

Art Workshop
- 371.140 (H) Cartooning

Computer Science
- 600.107 (E) Intro to Programming in Java
- 600.211 (E) UNIX Systems Programming
- 600.226 (EQ) Data Structures
- 600.363 (EQ) Introduction to Algorithms

Earth and Planetary Sciences
- 270.114 (N) A Guided Tour of the Planets

Economics
- 180.101 (S) Elements of Macroeconomics
- 180.102 (S) Elements of Microeconomics
- 180.301 (S) Microeconomic Theory
- 180.302 (S) Macroeconomic Theory
- 180.314 (SQ) Mathematical Economics
- 180.334 (SQ) Econometrics
- 180.367 (S) Investments and Portfolio Management

Geography and Environmental Engineering
- 570.409 (EQ) Facility Siting Models
- 570.495 (EQ) Mathematical Foundations for Public Decision Making

Mathematics
- 110.304 (Q) Elementary Number Theory

Philosophy
- 150.118 (HQ) Intro to Formal Logic

Psychology
- 200.101 (SN) Intro to Psychology
- 200.212 (S) Abnormal Psychology

Writing Seminars
- 220.105-106 (HW) Introduction to Fiction and Poetry

7 COMBINED BACHELOR'S-MASTER'S PROGRAM

Highly motivated and exceptionally qualified undergraduates may apply for admission to the Combined Bachelor's-Master's Program in Applied Mathematics and Statistics. Interested students are encouraged to apply in the fall semester of the junior year, but no later than November 1 of the senior year, and *must* apply and be accepted at least one semester before completing all requirements for the Bachelor's degree.

The requirements consist of those for the Bachelor's and Master's programs. See the university catalog, or consult your faculty advisor in the department for the details of the Master's program in Applied Mathematics and Statistics.

Please note that the School of Engineering places a limit on the number of courses that may be double-counted for two different degrees. Please see http://engineering.jhu.edu/graduate-studies/academic-policies-procedures-graduate/ for details.

Once accepted into the combined program, any coursework taken throughout the student's undergraduate career at Hopkins that fulfills the requirements for the dual degree may be applied to the overall degree requirements. According to university policy for the awarding of undergraduate degrees, the student must be a full-time resident student during his or her last semester of the combined program.

If the student decides to withdraw from the combined program, the Bachelor's degree will be issued, as long as all requirements are met, as of the term the student withdrew (not retroactively). A student who withdraws from the combined program may not re-enter the combined program, and if the student wishes to continue graduate study, he or she will need to apply as a graduate student.

If an undergraduate student completes the Bachelor's degree and graduates, the student is no longer eligible to apply for the combined program, but may apply for admission as a graduate student.

Forms and procedures for admission to the combined Bachelor's-Master's program may be obtained online at http://engineering.jhu.edu/ams/bachelors-masters-program/.

8 UNDERGRADUATE RESEARCH

Supervised research is an opportunity for you to become involved in research projects carried out here at Homewood. It should be discussed with the relevant faculty member well before the pertinent registration period. In all cases, supervised research is established by an agreement between you (the student) and the person with whom you wish to work. That agreement should specify what you are going to do, how much time you will spend doing it, when you are expected to be present, what you are going to *give* to that person (e.g., meeting times, a paper, the results of an experiment, etc.), and what you are going to *get* from that person (e.g., supervision, readings, guidance in pursuing the project, etc.).

In order to register for 553.500 Undergraduate Research, you must fill out the Undergraduate Research/Independent Study Supplemental Registration Form, which can be obtained at the Registrar's Office. You will also submit an add/drop form if necessary.

The number of credits for supervised research, ranging from 1 to 3, is determined at the end of the semester. Each 40 hours of work is worth one credit. Because the semester is about 13 weeks long, each credit at a weekly rate is about 3 hours per week. The Summary Report of Independent Work Form, which can be obtained from the Registrar's Office, must be completed for you to receive a grade.

9 ADVISING PROCEDURES

Every undergraduate student majoring in Applied Mathematics and Statistics must follow a program approved by the faculty advisor. The advisor is assigned by the Academic Program Coordinator when the student enters the department. A student may change advisors with the approval of the departmental Director of Undergraduate Studies. The student is responsible for planning a program of study in cooperation with the faculty advisor.

Courses in the School of Professional Studies or Summer Session at Hopkins or elsewhere can be counted toward major requirements only with the advisor's prior written approval. Courses taken without written approval of the advisor may not be acceptable. Typically, written approval is indicated by the advisor's signature on the course registration form or add/drop form.

Unless prior arrangements have been made, faculty members can approve course registration forms and add/drop slips only for their own advisees. Faculty in the Department of Applied Mathematics and Statistics make every effort to be available to their advisees during posted office hours, particularly during the advising periods scheduled in the Johns Hopkins University Catalog. Students should make use of these scheduled advising periods, and are welcome to make appointments for advising at other times.

Students are strongly advised to maintain a portfolio consisting of course projects, exams, and other work, a checklist of graduation requirements, and a current resume. Each student is expected to bring this portfolio when meeting with the advisor during the advising period in each semester. The advisor will review the portfolio, discuss the student's progress, and offer advice accordingly.

10 CAREER PLANNING

Career Center

The Career Center in Garland Hall can help you in planning your career. We strongly urge you to visit the representatives of this office several times while you are at Hopkins. Their services are available at no charge. They should be able to provide you information about the types of careers that are most suited for you and the steps you should take to prepare for those careers. Most students report that this office has been very helpful.

The department strongly recommends that students take advantage of the Career Center's assistance in preparing a resume during the freshman year, and use the office to help arrange summer jobs and internships.

Career Opportunities

Applied Mathematics and Statistics at Johns Hopkins prepares its undergraduates with a broad intellectual training in modern-day applied mathematics and offers them many career opportunities. We summarize some of these opportunities and encourage Applied Mathematics and Statistics undergraduate majors to talk to and solicit advice from the faculty about further career possibilities and their individual aspirations.

There is a wide range of opportunities that come in different forms and with varied job titles and descriptions. Many consulting, financial, technical, insurance, management, pharmaceutical, and computer firms, as well as research laboratories and government agencies, employ undergraduates with a solid quantitative background. Applied Mathematics and Statistics majors are particularly welcome and in fact have a strong advantage in these positions. Invariably, some experience with computers and computing is desirable. In management firms, one is often hired as a management trainee or a quantitative analyst; tools needed include statistics, operations research, economics, and computer technology. In the insurance industry, the actuarial profession is a promising field for an Applied Mathematics and Statistics major to enter. To become a fully-qualified actuary, one has to pass a sequence of ten examinations, the first few of which involve several mathematical topics (such as calculus, probability, statistics, operations research, numerical analysis, and theory of interest); Applied Mathematics and Statistics majors have a distinct advantage on these exams.

(1) Management and Finance. More and more, present-day managers must use mathematics-related tools involving statistics, operations research, and computer technology. Often, a business school has to teach these subjects to its students because the students have inadequate training in mathematics. As a result, a student with an undergraduate major emphasizing mathematics has a strong advantage when entering the field of management.

The same is true of the related fields of economics and finance. In fact, the job title Mathematical Economist has recently been coined for a position that requires strength in both mathematics and economics. A large proportion of Hopkins Applied Mathematics and Statistics majors work for two or three years following graduation as financial analysts and then enroll in a business school's MBA program. Several alumni hold top management positions at T. Rowe Price, Alex. Brown, and Morgan Stanley. Others are CEOs of companies such as MCI Communications, Pizza Hut, TCI Communications, and HCIA (Health Care Information Analysis).

(2) Actuary. Most actuaries work for the insurance and financial industries, although there are other possibilities. Ordinarily, one needs a B.S. in mathematics or economics, with knowledge of linear algebra and statistics, to enter this field. One is hired as an actuarial trainee, and is paid while being trained. There is a sequence of exams, offered by the Society of Actuaries, that one takes to become a fully qualified actuary. Several Hopkins Applied Mathematics and Statistics students have been able to pass four to six examinations during their undergraduate programs.

Coursework may replace certain actuarial exams, if the courses have been approved by the Society of Actuaries' Validation by Educational Experience (VEE) program. Please visit http://www.soa.org/education/exam-req/edu-vee.aspx to view the current Directory of Approved VEE Courses/Experiences.

(3) Industry and Government. There are a number of positions in government and industry for mathematicians with a Ph.D. degree. Such large research-oriented institutions as IBM, Bell Labs, Lockheed, and Rand Corporation hire Ph.D. mathematicians, both pure and applied, to be part of their research teams.

For mathematicians with a B.S. or M.S. degree there are many varied opportunities. Almost all positions at this level require training in some field of applied mathematics, along with some experience with computers. Although the areas involved, and the job titles, overlap, they can be classified roughly as follows:

Statistician. Job opportunities, both in the public and private sectors, are very good for students with undergraduate training in statistics, and even better for those with master's degrees. The federal government is one of the chief employers of statisticians; statisticians are found in the National Institute of Standards and Technology, the Bureau of the Census, the Bureau of Labor Statistics, the Department of Defense, the Department of Agriculture, and many other branches of government. In industry, statisticians are likely to be involved in such programs as the sound design of industrial experiments, the analysis of data relating to safety and efficiency, the design and analysis of data from clinical trials in pharmaceutical companies, and the design of statistically sound quality-control programs.

Operations Researcher. (This person may have a different job title, such as Operations Analyst or Systems Analyst.) There is a growing demand for this type of mathematician. Operations research is sometimes called the Mathematics of the Decision Sciences. It involves the use of mathematics, statistics, and computer science, with an emphasis on how to quantify things so as to make decisions. An undergraduate major in applied mathematics, plus graduate work in operations research, is the appropriate preparation for this field.

Classical Applied Mathematician. Traditionally, this title has meant a mathematician with a differential equations and physics/engineering orientation. This is a fundamental field in industry; there is a tremendous interest in solving equations of motion and those of steady-state fields. In the last three decades, the computer has made formerly impractical problems routinely solvable. The mathematician has much to contribute toward understanding the various methods of solution and finding which problems are best solved by which method.

Computer Mathematician. (This person may have a job title such as Systems Programmer or Systems Analyst.) The first requirement for entering this field is the ability to program a computer. Most young computer mathematicians at the B.S. or M.S. level are in fact initially *hired* as computer programmers. Those with a good mathematics background can quickly work themselves up beyond this level. Studies in discrete mathematics, numerical analysis, and algorithms can be especially useful in this regard.

There is a wealth of genuine mathematical problems in computer programming involving logic, combinatorics, number theory, and algebra. Many users of computers do not understand the logic of algorithms or how to estimate errors in approximations. They routinely use the most available computer program, regardless of its real applicability. Someone who can understand poorly worded problems and translate them into efficient algorithms becomes valuable.

(4) Teacher. Statistics indicate that high school teaching in many fields is overcrowded at present. This is, however, not true for mathematics. Perhaps because jobs in industry are so attractive, high schools are currently having a difficult time finding enough mathematics teachers. A Bachelor's degree is needed for

this field, and an M.S. or M.A. is desirable. Here, too, competence with computers and computing is a valued asset.

(5) College Professor. The Ph.D. degree is usually required for positions in a college or university. A strong commitment to both teaching and research is usually expected. At some colleges, mathematics instruction is all done within the Department of Mathematics. At others, mathematicians may hold positions in departments with such titles as Department of Statistics, Department of Applied Mathematics, Department of Mathematical Sciences, Department of Computer Science, Department of Operations Research, or even Department of Mathematical Biology. The demand for professors is at present small but steady. Only the better students should plan for a career in this field.

Placement of Graduates

A list of employers of Hopkins Applied Mathematics and Statistics graduates, though limited by response rate, may be more meaningful than summaries of the general employment situation for mathematicians.

Students in the graduating classes of recent years were offered positions at the following companies:

MicroFocus
Statista
Cigna
Morgan Stanley
Booz Allen Hamilton
Bloomberg LP
Oath
Discover Financial Services
IBM
Emergency Medical Assoc
DC Energy
AIG
Caesar's Entertainment
Navigator Consulting
Amazon
Brendan Cryan & Co.
Confluent
L. Livermore National Lab
McKinsey & Co.
Lambda Labs
Fed Energy Regul Commis
Wunderman
Janney Montgomery Scott
Foundry.ai
Capgemini Govt Solutions
Guggenheim Partners
Mercer
Apple
Ernst & Young
srcLogic
Miami Marlins
Deep Mind
FactSet Research Systems
Facebook
DRW
Atana
PNC
Prudential
Beghou Consulting
Tecolote Research
NIH
J.P. Morgan
Bain & Co.
Indiggo
Verb Surgical Inc.
Microsoft
Point72 Asset Mgmt
EY Advisory & Consulting
Google
Gartner
Insight Strategy Advisors
Qualtrics
Baltimore Orioles
New York Life
Insight
Capgemini Government Solutions
Capital Group
Bridgewater
Boston Consulting
Deloitte
PIMCO
Epic Systems
Goldman Sachs
Hewlett Packard
Dean & Co
JH Applied Physics Lab
JHU Center for Imaging Science
Deutsche Bank
Sequoia China
Navigator Mgmt Partners
Accenture
Raining Rose
Rubrik
FranData
Mu Sigma, Inc.
Nordstrom
Pinterest

Graduate Studies in Applied Mathematics and Statistics

Like majors from other disciplines, an Applied Mathematics and Statistics undergraduate major may wish to continue his/her study by pursuing a graduate degree or entering a professional field such as management, medicine, or law. A distinct advantage of having Applied Mathematics and Statistics training is that there are diverse disciplines in which one can pursue graduate studies. In terms of graduate degrees, a Master's degree is usually a terminal degree and is recommended for someone who wants to learn more about a subject area but has no special interest in doing research in that discipline. Most often, a doctoral degree is required for anyone who is interested in teaching at the college or university level. Some Master's degree holders decide later in their careers to seek a Ph.D.

After one has decided to pursue a graduate degree, the next decision to be made is the subject and the institution. Usually, the faculty are the best source for such information, especially as a first step in the entire planning process. The faculty are able to give general information and advice on disciplines, schools, post-graduate opportunities, and career guidance. The Internet is a good source for information about individual schools. Applied Mathematics and Statistics majors from Hopkins have gone on to graduate schools in diverse disciplines including industrial engineering, operations research, statistics, computer science, economics, management, mathematics, and medicine. Some remain at Hopkins while most enroll at other schools.

Important Note: Financing a mathematics graduate education is not likely to be a problem because teaching assistantships and fellowships are widely available at most universities. Most Hopkins students applying to graduate schools receive offers of full tuition support and full living expenses. Locations of some strong graduate programs in Applied Mathematics and Statistics, by field, are:

Statistics	Stanford University
	University of California at Berkeley
	Purdue University
	University of Chicago
	Iowa State University
	University of Washington
	Carnegie Mellon University
Discrete Mathematics	Massachusetts Institute of Technology
	Rutgers University
	University of Waterloo
	Emory University
	Georgia Institute of Technology
Operations Research	Cornell University
	Massachusetts Institute of Technology
	University of California at Berkeley
	Georgia Institute of Technology
	Stanford University
	Princeton University
	Rutgers University
Applied Mathematics	Brown University
	Rice University
	New York University (Courant Institute)
	Princeton University
	University of California at Berkeley
	University of California at Los Angeles

Master's programs in financial mathematics have been introduced at:

Carnegie Mellon University
University of Chicago
Cornell University
Columbia University
University of Toronto
Princeton University

11 DEPARTMENTAL SERVICES

E-mail Notices

Undergraduate majors are routinely sent e-mail notices of departmental events (such as seminars, picnics, parties, and special lectures), permanent and summer job openings, information regarding new courses, course registration, etc.

Grader and Teaching Assistant Positions

The Department regularly hires outstanding undergraduate majors as teaching assistants and graders for its lower division courses, particularly for 553.111-112 Statistical Analysis courses. These positions typically pay for 10 hours per week. Work-study eligibility is not required. If you are interested, please visit http://engineering.jhu.edu/ams/about/employment-opportunities/ for application information.

Job Information

Job postings received by the department area available on the boards on the second and third floors of Whitehead Hall.

Seminar Notices

Notices of seminars in various JHU departments and neighboring universities are posted on the bulletin board in the hallway outside 100 Whitehead.

12 AWARDS AND HONORS

The Applied Mathematics and Statistics Department offers four awards open to undergraduates, which are awarded at the annual Engineering School Convocation at the end of each spring semester.

Eliezer Naddor Prize

The Naddor Prize is awarded to junior Applied Mathematics and Statistics Department majors who have made significant accomplishments in academic endeavors or extracurricular activities. It is named in honor of the late Professor Naddor, a long-time operations research professor in the department, who was the first recipient of a Ph.D. in Operations Research in the United States. Professor Naddor was an expert in inventory theory.

Applied Mathematics and Statistics Achievement Award

This award is made for outstanding achievement by a graduating Applied Mathematics and Statistics Department major, with multiple awards possible in a single year. The award consists of a certificate and a monetary award. The Achievement Award has been made since 1975, with all awardees' names commemorated on a plaque on display in the Applied Mathematics and Statistics office.

AMS Mathematical Modeling Contest Prize

This annual prize is awarded to the team of Johns Hopkins students that is judged by a committee in the department to have demonstrated the best performance in the year's COMAP Mathematical Contest in Modeling.

Professor Joel Dean Award for Excellence in Teaching

This award is given to faculty and teaching assistants who demonstrate an intense devotion to teaching and talent for making mathematics more understandable.

Appendix

Distribution Requirements (BS in Applied Mathematics and Statistics)

Students pursuing a BS must complete the following distribution requirements:

- 18-21 credits (6 courses at least 3-credits each) designated H and/or S. Although language elements courses do not carry an area designator, engineering students may use these courses as substitutes for humanities courses in meeting the distribution requirement. **
- 12 credits designated N (Reminder: these must be taken for a letter grade and passed with a C- or better). Intersession courses only graded on an S/U basis may also be used toward this requirement when passed with an S.
- 2 writing intensive courses

Distribution Requirements for (BA in Applied Mathematics and Statistics)

Students pursuing a BA must complete the following distribution requirements:

- 18-21 credits (6 courses at least 3-credits each) designated H and/or S. Although language elements courses do not carry an area designator, engineering students may use these courses as substitutes for humanities courses in meeting the distribution requirement. **
- 4 writing intensive courses

http://e-catalog.jhu.edu/undergrad-students/academic-policies/requirements-for-a-bachelors-degree/

** The following specific course pairings of a 2-credit course and a 1-credit course have been approved to count towards the H/S distribution requirements in place of a single 3-credit course:
Set One
EN.660.400 Practical Ethics for Future Leaders (2 cr.)
EN.660.406 Practical Ethics for Future Leaders - Special Topics (1 cr.)
and
Set Two
EN.660.400 EN.660.400 Practical Ethics for Future Leaders (2 cr.)
EN.520.404 Engineering Solutions in A Global, Economic, Environmental, and Societal Context (1 cr.)