CAMS Applied Statistics (rationale and motivation)

As humans have developed cheaper and smaller sensors, web cameras and other data collection devices, the amount of data available to be analyzed and understood has exploded. William and Mary has received grant funding for two large projects centered on "big data"—AidData and EXTREEMS-QED.

AidData is a collaborative initiative that makes aid information more accessible and usable to a wide range of stakeholders and creates tools that enable users to more effectively target, coordinate, deliver, and evaluate aid. The College of William & Mary, Brigham Young University, and Development Gateway are the institutional members of the AidData partnership.

Expeditions in Training, Research, and Education for Mathematics and Statistics through Quantitative Explorations of Data (EXTREEMS-QED) program is an educational program supported by National Science Foundation to support efforts to educate the next generation of mathematics and statistics undergraduate students to confront new challenges in computational and data-enabled science and engineering. EXTREEMS-QED projects will enhance the knowledge and skills of mathematics majors through training that incorporates computational tools for analysis of large data sets and for modeling and simulation of complex systems.

Both the above multi-year research funded activities significantly involve undergraduate students in research activities. It is unclear whether these grants have driven the increased enrollment in The College's statistics courses or not, but demand has increased. The two key classes in the Applied Statistics Track are Math 401/501 (calculus-based probability) and Math 452/552 (mathematical statistics). Both of these classes have seen record enrollments during the 2013–2014 academic year. In the spring 2014 term, there are $38 + 26 = 64$ enrolled in Math 401/501, and 31 enrolled in Math 452/552. Undergraduate students with an interest in statistics often express an interest in actuarial science. There are currently 17 students who have signed up to take the introductory actuarial exam in May of 2014, breaking the previous high of 11 students taking the exam. Nationally, the number of statistics majors graduating annually has nearly doubled since 2007. We have noticed a marked increase in the number of high school students considering matriculation at William and Mary wanting to know if a major in statistics is possible.

Creating an Applied Statistics Track will provide a major option for undergraduates with an interest in statistics, "big data", and actuarial science.

CAMS Mathematical Biology (motivation and rationale)

In the fall of 2010, the College of William & Mary was awarded $1.2 million from the Howard Hughes Medical Institute for the advancement of undergraduate science education and outreach in the biological sciences and other scientific disciplines. As the fourth consecutive grant, this funding expanded undergraduate research opportunities, led to new and enhanced interdisciplinary course offerings, and offered faculty development initiatives. All four grants, but particularly the 2010 grant, stress the importance of interdisciplinary and integrative approaches to education and research - and to increasing diversity in the sciences. See `http://hhmi.wm.edu/` for additional information on the activities generated as a result of the HHMI grants.

The HHMI grants have let to a number of new synergistic activities. On the curricular side, a number of biomathematics courses have been developed– Math 131 and 132 Calculus with a focus on biological applications; Math 345 Introduction to Mathematical Biology; Apsc/Biol 351 Cellular Biophysics and Modeling; Apsc 455 Population Dynamics; Apsc 456/Biol 404 Random Walks in Biology; and Biol 425 Intro to Biostatistics. Collaborative research projects involve faculty from VIMS, mathematics, physics and biology. Research teams typically include faculty from multiple departments and/or VIMS and include undergraduate Arts and Sciences students. Faculty, graduate students and undergraduate students all particpate in a biomath journal club that has met for several years. The lunch discussions on Fridays have met in both Jones Hall and ISC and provide a platform for these research groups to form, present preliminary results and discuss published scientific papers. See `http://wmpeople.wm.edu/site/page/biomath/home` for additional information.

Creating a Mathematical Biology Track will provide undergraduates a major option in this emerging academic discipline.

Computational and Applied Mathematics and Statistics

Faculty

• Director: Rex K. Kincaid (Mathematics)

View the Faculty in the Mathematical Biology Track

- **Advisory Committee**
- M. Drew LaMar (co-Director, Biology Department)
- Harmony Dalgleish (Biology Department)
- Margaret Saha (Biology Department)
- Sarah L. Day (co-Director, Mathematics Department)
- Gregory D. Smith (Applied Science Department)
- Leah B. Shaw (Applied Science Department)
- Junping Shi (Mathematics Department)
- Mainak Patel (Mathematics Department)

View the Faculty in the Applied Statistics Track

- **Advisory Committee**
- Tanujit Dey (co-Director, Mathematics Department)
- Ross Iaci (co-Director, Mathematics Department)
- Lawrence M. Leemis (Mathematics Department)
- Carlisle Moody (Economics Department)
- Robert L. Hicks (Economics Department)

The CAMS (Computational and Applied Mathematics and Statistics) major is by nature inter-disciplinary. In CAMS, applications are the primary driver of the research agenda for scholarly activity. The CAMS program supports a collaborative, multi-disciplinary, and integrative approach to teaching and research in applied and computational mathematics, operations research, mathematical biology and statistics. Course work and research experiences in CAMS provide a strong base in both the knowledge and practical skills necessary to make important contributions to mathematics, industry and the sciences. There are two tracks within the CAMS program– Mathematical Biology and Applied Statistics.

Mathematical Biology aims at modeling natural, biological processes using mathematical techniques and tools. It has both practical and theoretical applications in biological research. Applying mathematics to biology has a long history, but only relatively recently has there been an explosion of interest in the field. Some reasons for this include: the explosion of data-rich information sets, due to the genomics revolution, which are difficult to understand without the use of analytical tools; recent development of mathematical tools such as chaos theory to help understand complex, nonlinear mechanisms in biology; an increase in computing power which enables calculations and simulations to be performed that were not previously possible; and an increasing interest in computer experimentation due to the complications involved in human and animal research.

The Applied Statistics Track provides a major option for undergraduates with an interest in statistics, "big data", and actuarial science. As humans have developed cheaper and smaller sensors, web cameras and other data collection devices, the amount of data available to be analyzed and understood has exploded. Statistics is the mathematical science that pertains to the collection, analysis, interpretation, explanation, and presentation of data. Because of its empirical roots and its focus on applications, statistics is typically considered a distinct mathematical science rather than a branch of mathematics.

For advice and further information contact the CAMS Director, Professor Rex K. Kincaid (Mathematics), the CAMS Applied Statistic track director, Professor Ross Iaci (Mathematics), or the CAMS Mathematical Biology track directors Professor M. Drew Lamar (Biology) and Professor Sarah Day (Mathematics).

Programs

- link to CAMS Applied Statistics major track
- link to CAMS Mathematical Biology major track
- link to CAMS Mathematical Biology minor

CAMS Applied Statistics Track

The minimum number of credit hours for the major is 30 required credit hours and 20 credit hours of prerequisites. Proficiency requirements are typically fulfilled by completing an additional 13 credit hours.

add link to major declaration form here

Major Writing Requirement

The upper-division writing requirement may be satisfied in one of the following ways:

◦ Completion of ECON 308, ECON 380, MATH 352 or MATH 459 with a grade of C- or better, or
◦ Completion of CAMS 495 and CAMS 496, which requires the writing of an Honors thesis.

Major Computing Requirement

Proficiency in a high-level programming language and fundamental concepts in data structures at the level of CSCI 141 and CSCI 241 is required. This is normally done by taking and passing these courses.

◦ CSCI 141 Computational Problem Solving (4)
◦ CSCI 241: Data Structures (3)

Major Mathematics Requirement

Proficiency in linear algebra and multivariable calculus at the level of MATH 211 and MATH 212 or MATH 213 is required. This is normally done by taking and passing these courses.

◦ MATH 211 Linear Algebra (3) and
◦ MATH 212 Multivariable Calculus (3) , or
◦ MATH 213 Multivariable Calculus for Science and Mathematics (4)

Minimum Course Prerequistes

◦ ECON 101 Principles of Microconomics (3)
◦ ECON 102 Principles of Macroeconomics (3)
◦ ECON 303 Intermediate Microeconomic Theory (3)
◦ MATH 111 Calculus I (4)
◦ MATH 112 Calculus II (4)
◦ MATH 214 Foundations of Mathematics (3)

Note: Selection of certain electives may require additional prerequisite courses.

Economics (3 courses)

◦ ECON 308 Econometrics (3)
◦ ECON 380 Experimental Economics (3)
◦ ECON 407 Cross Section Econometrics (3)
◦ ECON 408 Time-Series Econometrics (3)
◦ ECON 415 Applied Financial Derivatives (3)

Required Probability and Statistics (2 courses)

◦ MATH 401: Probability (3)
◦ MATH 452: Mathematical Statistics (3)

Other Mathematics (2 courses)

◦ MATH 352: Data Analysis (3)
◦ MATH 424: Introduction to Operations Research: Stochastic Modeling (3)
◦ MATH 459: Topics in Statistics (3)

Computer Science (3 courses)

◦ CSCI 301: Software Development (3)
◦ CSCI 303: Algorithms (3)
◦ CSCI 421: Database Systems (3)
◦ CSCI 426: Simulation (3)

Students are encouraged to consider the following graduate courses. These courses may be taken by completing this form.

◦ CSCI 668: Reliability Theory (3)
◦ CSCI 678: Statistical Analysis of Simulation Models (3)
◦ CSCI 688: Linear Regression (3)
◦ CSCI 688: Design of Experiments (3)

Note: Credit for INTR 495-496 Honors may substitute for any two elective courses, as long as the two courses are not in the same category. In addition, with advisor approval, students may replace one elective course with one or more independent study or research credits, which must total at least 3 credits.

CAMS Mathematical Biology Track

The minimum number of credit hours for the major is 30 required credit hours and 14 credit hours of prerequisites. Proficiency requirements are typically fulfilled by completing an additional 13 credit hours.

Add link to Major declaration form here.

Major Writing Requirement

The upper-division writing requirement may be satisfied in one of the following ways:

- Completion of BIOL 404 or MATH 345 with a grade of C- or better, or
- Completion of CAMS 495 and CAMS 496, which requires the writing of an Honors thesis.

Major Computing Requirement

Proficiency in a high-level programming language and fundamental concepts in data structures at the level of CSCI 141 and CSCI 241 is required. This is normally done by taking and passing these courses.

- CSCI 141 Computational Problem Solving (4)
- CSCI 241: Data Structures (3)

Major Mathematics Requirement

Proficiency in linear algebra and multivariable calculus at the level of MATH 211 and MATH 212 or MATH 213 is required. This is normally done by taking and passing these courses.

- MATH 211 Linear Algebra (3) and
- MATH 212 Multivariable Calculus (3) , or
- MATH 213 Multivariable Calculus for Science and Mathematics (4)

Minimum Course Prerequisites

- BIOL 220 Introduction to Organisms, Ecology, Evolution (3)
- BIOL 225 Introduction to Molecules, Cells, Development (3)
- Math 131 Calculus I for Life Sciences (4)
- Math 132 Calculus II for Life Sciences (4)

Note: Selection of certain electives may require additional prerequisite courses.

Required Mathematical Modeling (2 courses)

◦ APSC/BIOL 351: Cellular Biophysics and Modeling (3)
◦ APSC 456/BIOL 404: Random Walks In Biology (3)

and one of

◦ BIOL 404: Introduction to Quantitative Biology (3) or
◦ MATH 345: Introduction to Mathematical Biology (3-4)

Statistics and Data Analysis (2 courses)

◦ BIOL 425: Introduction to Biostatistics (3-4)
◦ MATH 351: Applied Statistics (3)
◦ MATH 352: Data Analysis (3)
◦ MATH 401: Probability (3)
◦ MATH 452: Mathematical Statistics (3)

Note: Math 351 cannot be taken for credit if credit for Math 401 has already been given.

Computational Electives (1 course)

◦ CSCI 303: Algorithms (3)
◦ PHYS 256: Practical Computing for Scientists(3)
◦ CSCI 426: Simulation (3)
◦ CSCI 520: Computing in Operations Research (3)

Biology (Any 2 BIOL 300 level courses or above). Examples include:

◦ BIOL 310: Molecular Cell Biology (3)
◦ BIOL 312: Evolution of Organisms (3)
◦ BIOL 401: Evolutionary Genetics (4)
◦ BIOL/CHEM 414: Biochemistry (3)
◦ BIOL 417: Population and Community Ecology (4)
◦ BIOL 442: Molecular Genetics (3)
◦ BIOL 445: GIS for Biologists (3)
◦ BIOL 452: Self-Organization in Life and Chemical Sciences (3)

Applications and Models (2 courses)

◦ APSC 312: Medical Imaging (3)
◦ APSC 327: Introduction to Laser Biomedicine (3)
◦ APSC 450: Computational Neuroscience (3)
◦ CHEM 341: Physical Chemistry for Life Sciences (3)

- CHEM/BIOL 414: Biochemistry (3)
- PHYS 403: Statistical Mechanics and Thermodynamics (3)
- MATH 302: Ordinary Differential Equations (3)
- MATH 413: Introduction to Numerical Analysis I (3)
- MATH 414: Introduction to Numerical Analysis II (3)
- MATH 441: Ordinary Differential Equations II (3)
- MATH 442: Partial Differential Equations (3)
- MATH 410/APSC 490: topics courses (3)

Note: Credit for INTR 495-496 Honors, with a faculty advisor approved the the Mathematical Biology track director, may substitute for any two elective courses, as long as the two courses are not in the same category. In addition, with advisor approval, students may replace one elective requirement with one or more independent study or research credits, which must total 3 credits.

CAMS Mathematical Biology, Minor

Students must declare this minor before the beginning of preregistration for the final semester of their senior year by submitting a CAMS Mathematical Biology Minor Declaration form to the Director of Interdisciplinary Studies (Professor Schwartz in the Charles Center). Electives are to be selected by each student in consultaion with a member of the CAMS Mathematical Biology advisory committee. This minor is suitable for those students interested in learning how mathematical modeling, data analysis and computer simulation are used as tools in solving biological problems.

View minor declaration form here.

Required Credit Hours: 18

Core Requirements (12 or more credits):

The minor requires 6 or more additional credits in pre-requisites: MATH 111 or 131, MATH 112 or 132, and possibly BIOL 230 and BIOL 225.

Mathematical Modeling (2 courses)

◦ BIOL 404: Introduction to Quantitative Biology (3) or
◦ MATH 345: Introduction to Mathematical Biology (3-4)

◦ APSC 351: Cellular Biophysics and Modeling (3) or
◦ BIOL 351: Cellular Biophysics and Modeling (3)

◦ APSC 456: Random Walks In Biology (3) or
◦ BIOL 404: Random Walks In Biology (3)

Programming (1 course)

◦ CSCI 141 Computational Problem Solving (4)
◦ PHYS 256: Practical Computing for Scientists (3)

Statistics and Data Analysis (1 course)

◦ BIOL 425: Introduction to Biostatistics (3-4)
◦ MATH 106: Elementary Probablity and Statsitics (3)
◦ MATH 351: Applied Statistics (3)
◦ MATH 352: Data Analysis (3)
◦ PSYC 301: Elementary Statistics (3)

Electives (2 or more courses)

Students must select two additional courses from the following three categories below:

1). One of the remaining Mathematical Modeling courses listed above

2). At most one BIOL 300 level or above course. Examples include:

- BIOL 310: Molecular Cell Biology (3)
- BIOL 312: Evolution of Organisms (3)
- BIOL 401: Evolutionary Genetics (4)
- BIOL/CHEM 414: Biochemistry (3)
- BIOL 417: Population and Community Ecology (4)
- BIOL 442: Molecular Genetics (3)
- BIOL 445: GIS for Biologists (3)
- BIOL 452: Self-Organization in Life and Chemical Sciences (3)

3). At most one course from the following list:

- APSC 312: Medical Imaging (3)
- APSC 327: Introduction to Laser Biomedicine (3)
- APSC 450: Computational Neuroscience (3)
- CSCI 241: Data Structures (3)
- CSCI 303: Algorithms (3)
- CSCI 426: Simulation (3)
- CHEM 341: Physical Chemistry for Life Sciences (3)
- CHEM/BIOL 414: Biochemistry (3)
- MATH 302: Ordinary Differential Equations (3)
- MATH 352: Data Analysis (3)
- MATH 401: Probability (3)
- MATH 413: Introduction to Numerical Analysis I (3)
- MATH 414: Introduction to Numerical Analysis II (3)
- PHYS 403: Statistical Mechanics and Thermodynamics (3)

Note: With advisor approval, students may replace one elective course with one or more independent study or research credits, which must total 3 credits.