Ph.D. Degree in
Interdisciplinary Applied Science and Mathematics
Full Program Proposal

Submitted by the
College of Science and Mathematics
Wright State University
Table of Contents

1. Program Rationale and Mission .............................................................................................................. 4
2. Proposed Curriculum ................................................................................................................................. 6
   Organization of the Curriculum .................................................................................................................. 6
   Degree Requirements ................................................................................................................................. 6
   Focus Area I – Materials and Nanoscale Science and Technology ......................................................... 8
   Focus Area II -- Modeling and Analysis for Physical and Biological Systems ........................................ 8
   Focus Area III -- Computational Problems in the Physical and Biological Sciences ............................. 9
3. Program Administration ............................................................................................................................... 13
   IASM Program Administration .................................................................................................................. 13
   IASM Program Director ............................................................................................................................ 13
   IASM Committee Structure ...................................................................................................................... 13
4. Need .......................................................................................................................................................... 15
   Local/Regional/National Need ................................................................................................................... 15
   Student Interest, Demand, & Institutional Need ......................................................................................... 15
   Hanover Research Feasibility Study .......................................................................................................... 16
   Applied Science and Mathematics Programs at Other Institutions ....................................................... 17
   Interdisciplinary Research ......................................................................................................................... 18
5. Prospective Enrollment ............................................................................................................................... 19
6. Access and Retention of Underrepresented Groups ................................................................................. 19
7. Program Faculty and Facilities ............................................................................................................... 20
8. Additional Needs for Faculty and Facilities ............................................................................................. 26
9. Projected Additional Costs and Evidence of Institutional Commitment .................................................. 26
10. Cited References .................................................................................................................................. 27
Appendix A: Sample Academic Programs of Study ..................................................................................... 28
Appendix B: Focus Area Courses .................................................................................................................. 31
Appendix C: IASM Core Course Syllabi ....................................................................................................... 33
Appendix D: IASM Program of Study Form .................................................................................................. 43
Appendix E: IASM Program Timeline .......................................................................................................... 45
Appendix F: Selected IASM Focus Area Course Descriptions .................................................................. 46
Appendix G: IASM Program Faculty Vitae .................................................................................................. 52
Appendix H: IASM External Advisory Board Letters of Support ............................................................... 52
1. Program Rationale and Mission

Now and in the future, highly skilled workers are, and will continue to be in high demand throughout the nation, and in Ohio in particular. Worldwide, economies must increasingly utilize technology to gain competitive advantage by developing new products, producing goods and delivering services ever more efficiently. In the Dayton area, the United States Air Force is a major driver of technology development. Wright Patterson Air Force Base (WPAFB) serves as a center for weapon systems acquisitions and aeronautical materials and systems research. Local private sector companies engage in the development, production and marketing of new high tech devices. Faculty and graduate students at Wright State University (WSU) and the University of Dayton are actively involved in the basic and applied research on which new technologies will be based.

In order to bolster economic expansion, the state of Ohio and the federal government are investing heavily in technologically oriented research and development. There is widespread and growing recognition that important large-scale problems such as energy independence, global environmental stress remediation, and medical care for an aging population will necessitate the active participation of scientifically sophisticated workers from a wide range of disciplines. To help train such skilled professionals capable of working in cutting-edge interdisciplinary fields, the proposed interdisciplinary Ph.D. program is structured around the following specific goals:

1. To prepare broadly trained, scientifically and technologically skilled professionals for careers in applied science in government and industry;
2. To provide a foundation for careers in basic scientific research;
3. To provide quantitative tools and knowledge to enhance workplace effectiveness;
4. To advance knowledge in basic and applied science and mathematics.

The proposed Ph.D. program is unique in its focus, building upon the recognized expertise of a core group of program faculty (See Appendix G.) primarily within the College of Science and Mathematics (CoSM), but faculty from other Wright State University colleges such as the College of Engineering and Computer Science will be recruited and invited to join the program. The program focuses on three areas of technological and scientific importance:

1. Materials and Nanoscale Science and Technology Development
2. Modeling and Analysis for Physical and Biological Systems
3. Computational Problems in the Physical and Biological Sciences

The program is designed primarily for students possessing a B.S. or M.S. degree in mathematics, physics or other related technical disciplines. The three focus areas are interdisciplinary by nature. They will provide students with the opportunity to develop high-demand quantitative skills in multiple applied scientific areas, while ensuring that they are well grounded in more traditional areas of mathematics, physics, chemistry, earth science, biology, and cognitive science. By integrating these areas, the program will emphasize detailed analyses of the mechanisms underlying important scientific phenomena.

Ph.D. Degree in Interdisciplinary Applied Science and Mathematics  Proposal Page 4
The interdisciplinary/multidisciplinary nature of high-impact scientific research and development is widely recognized, as is the need to connect basic and applied research. In commenting on its importance, a working definition of interdisciplinary research has been set forth in a National Academies’ report:

“Interdisciplinary research is a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice [1].”

The proposed program will encourage students to explore connections between scientific disciplines, as well as connections between basic and applied research.

The proposed Ph.D. program is timely and will provide Wright State with the opportunity to become competitive at a national level for research students and faculty. While WPAFB will likely remain the largest regional employer and a technological leader in the Dayton area, it is restricted by its inherent Department of Defense Mission from exploring many of the emerging technological fields (e.g., advanced energy technology, biomedicine, and bioengineering) that universities are aggressively pursuing. By emphasizing an interdisciplinary approach, Wright State expects to attract world-class faculty and to train and graduate top-notch researchers with the foundation and skills in the physical sciences and mathematics that will enable them to advance in their own and related technical fields.
2. Proposed Curriculum

With the ever accelerating rate of technological development evident today, even highly trained scientists entering business and industry cannot predict which of skill sets will be needed during their careers. It is highly desirable to equip students with a broad exposure to current interdisciplinary scientific problems and provide them with the tools necessary to become successful analysts and researchers, including the ability to adapt and update their knowledge and technical skills in the workplace. This requires a strong foundation in applied mathematics and physics, a foundation that was fundamental to U.S. scientists and engineers in the 1950’s through the 1980’s. All students will receive interdisciplinary training through coursework and research, in addition to professional development in terms of oral and written presentation and reporting skills. The IASM Program Degree Requirements are listed below. The subsequent section provides a more comprehensive description of the curriculum.

Organization of the Curriculum

The Interdisciplinary Applied Sciences and Mathematics (IASM) program will provide students with an interdisciplinary academic and research experience via a common core set of courses and a choice of one of three focus areas in which the student will obtain rigorous course preparation sufficient to support their chosen topic for dissertation research. The core and focus area courses have been chosen so that students will gain sufficient breadth in science and mathematics while also obtaining academic experience in applying quantitative analysis, modeling, and computational methods to complex problems in the physical and biological sciences. Each focus area has a designated list of course work appropriate to the possible research projects/advisors for the given area (See Appendix B.). As the IASM students transition to research, they will also complete course work enhancing their skills in research methodology, ethics, and scientific writing. This section outlines the program degree requirements including descriptions of the core and focus area courses. Admissions requirements as well as program milestones such as the qualifying and candidacy exams will also be presented. Detailed programs of study, course descriptions, and syllabi can be found in Appendices of this document where noted.

To earn the Ph.D. in Interdisciplinary Applied Sciences and Mathematics, students must satisfy the following requirements.

Degree Requirements

1. **Core Courses:** MTH 6060 Mathematical Modeling, MTH 6150 Scientific Computation, IASM 8000 Introduction to Research I, IASM 8010 Introduction to Research II, IASM 8100 Graduate Seminar (2 semesters).

2. **Focus Area Courses:** 8 courses chosen from Focus Area courses, with at least 2 of these courses chosen from an area different from the student’s own focus area.

3. **Electives:** 4 approved courses, numbered 6000 or above (Please consult the Appendix for a course listing), offered by science, math, or engineering academic departments. An internship is a recommended substitute for up to 2 of these courses.

4. **Dissertation Research:** IASM 8400 Dissertation Research (At least 40 credit hours).
The IASM curriculum is based on four types of courses: **Core**, **Focus Area**, **Elective**, and **Research**. All IASM program students will take the same **Core Courses** regardless of the student’s chosen focus area. These **Core Courses** are:

- Math 6060 Mathematical Modeling
- Math 6150 Scientific Computation
- IASM 8000 Introduction to Research I
- IASM 8010 Introduction to Research II
- IASM 8100 Graduate Seminar

Descriptions of these courses may be found in the Appendix B. Students will take 6 courses associated with their selected **Focus Area** and 2 additional courses from one of the remaining two Focus Areas. Students will select 4 **Elective** courses, at the 6000 level or above, from an approved list of science and engineering courses as designated by each Focus Area. An internship (IASM 8200) will be a recommended substitute for up to 2 of these **Elective** courses.

Depending on students’ chosen research Focus, the total required academic (non-research) course hours for the program will be on the order of 48 hours. This amount of academic course work is similar in number to that required in typical Ph.D. programs in Mathematics and the Physical Sciences at Tier 1 Research universities \([2,3,4,5,6,7]\) as well as the existing Ph.D. in Engineering program at Wright State University \([8]\). IASM students will also be required to gain course credits by registering for Independent Research (IASM 8300) prior to passing the Qualifying Exams and Dissertation Research (IASM 8400) afterwards.

A significant part of the IASM curriculum’s **Core Courses** are designed to prepare students for their dissertation work by focusing on research methodology, ethics, scientific writing, and familiarization with current research topics. During their first year in the program, students will take IASM 8000 and 8010. In **Introduction to Research I** (IASM 8000), IASM students will be introduced to ongoing research activities within the three IASM Focus Areas and will receive presentations from IASM faculty. It will introduce students to research methods including literature research, data analysis, written presentations, and oral presentations. This course will aid students in the selection of his/her doctoral research director. Course content will also include research ethics which will emphasize the evaluation of hypothetical ethical case scenarios that arise in research environments. Class discussion will be based on integrating ethical policy and practices as they relate to research at Wright State and beyond. As part of this, student teams will each be given a hypothetical ethics case and be expected to develop a case study analyzing the situation. This course will also provide students with experience and guidance in scientific writing. Students will complete a minimum 4 page report summarizing the research of an IASM program faculty member in the format of an academic journal. For both written reports, students will be required to submit outlines and first drafts prior to submission of the revised final draft.

In **Introduction to Research II** (IASM 8010), students will focus on the development of research projects. Students will continue to gain exposure to the research activities of program faculty via seminars. In addition, student activity in the second semester will focus on the development of a “mock” research proposal. Each student will formulate a research question, conduct a literature review, and develop a research methodology and budget, while being mentored by a program faculty member. This proposal will be prepared in the form of a written proposal and also defended orally to classmates and a panel of program faculty. This course will also provide
students with experience and guidance in scientific writing. For both written reports, students will be required to submit outlines and first drafts prior to submission of the final draft.

All second-year students will take two semesters of IASM 8100, Graduate Seminar. Students, as well as faculty from the IASM program, will convene to learn, discuss, and critique current and evolving research in fields relevant to the IASM program mission as presented by an active and reputable scientific investigator. This seminar course will be centered on guest lecturers and student presentations.

The IASM curriculum is organized around the three focus areas as described below. In addition to completing the required coursework associated within each focus area, students will concentrate their research efforts in one of the focus areas. Students will develop programs of study commensurate with their research interests under the guidance of the Focus Area chair (Section 3 of this proposal) and advisor.

**Focus Area I – Materials and Nanoscale Science and Technology**

Students in Focus Area I (FAI) will conduct thesis work in fields such as sensor theory, biomolecular engineering, transport processes in noncrystalline materials, electromagnetic propagation in inhomogeneous media, spectroscopy, imaging, and device physics. While these topical areas focus on research traditionally found in engineering and physics programs, IASM students will work to develop and apply mathematical/computational models that either match or predict experimentally-derived data. The ability and necessity to develop complex predictive models based on experimental data has been more prevalent in recent years as it is often seen in research solicitations. FAI students, in order to prepare for research activities, may choose courses, in addition to the two core courses in Mathematical Modeling and Scientific Computation, in topics such as Applied Math, Electromagnetic Theory, Quantum Mechanics, Mathematical Physics, and Statistical Mechanics. Approved electives in this focus area include advanced physics, math, and chemistry courses in addition to special topics courses in fields such as ultrafast physics, geophysics, and nanoscience. A sample program of study for FAI is included in Appendix A. It should be noted that this, and other sample programs of study in Appendix A, assume that the student is well prepared and capable of working successfully under a rigorous course load. In practice, some students may satisfy the required program coursework at a slower pace.

**Focus Area II -- Modeling and Analysis for Physical and Biological Systems**

Research conducted by students who select Focus Area II (FAII) will focus on modeling and analysis of complex physical and biological systems including topics in nonlinear dynamics, complexity, transport processes, scattering, discrete dynamic systems, analysis under uncertainty, modeling of biological systems, biostatistics, cognitive modeling, and multi-scale physics. Students choosing FAII may choose courses, in addition to the two core courses in Mathematical Modeling and Scientific Computation, in topics such as Applied Mathematics, Statistical Mechanics, Numerical Analysis, and Real Analysis. Options for elective courses will include advanced courses in Biology, Biochemistry, and Earth/Environmental science. A condensed program of study for FAII is included in the Appendix A.
**Focus Area III -- Computational Problems in the Physical and Biological Sciences**

Research by students in Focus Area III (FAIII) will concentrate on topics such as inverse problems, system optimization, computational statistics, bioinformatics, computational biology, and cognitive processing. In addition to the two core courses in Mathematical Modeling and Scientific Computation, FAIII students may choose courses in Numerical Analysis, Biology, Applied Statistics and Biostatistics with approved electives ranging from geology to environmental statistics to cognition. A condensed program of study for FAIII is included in the Appendix A.

**Admission**

Admission to the Interdisciplinary Applied Science and Mathematics Ph.D. Program will be granted to students satisfying the admission requirements set forth by the Wright State University Graduate School and the IASM program. Applicants should come to the program with a good understanding of mathematics and science fundamentals including knowledge of differential equations and general physics. Courses in partial differential equations and mechanics are desirable additions, as well as exposure to a computational software package or programming language. Applicants’ academic records must clearly indicate a potential for success in IASM relevant research.

The minimum admission requirements set forth by the program are as follows:

- a B.S. or B.A. degree from an accredited institution in mathematics, science or engineering, with a minimum 3.0 grade point average in mathematics and science coursework, demonstrating a strong mathematics background, with academic training commensurate with IASM focus areas,

OR

- an M.S. degree from a mathematics or science program, with a minimum 3.25 grade point average in mathematics and science coursework, demonstrating a strong mathematics background, with academic training commensurate with IASM focus areas. M.S. applicants will be eligible for the waiving of required courses via transfer credit and possibly some program milestones at the discretion of the program director.

Additionally, students seeking admission will be required to submit:

- Academic Transcripts
- A Statement of Professional Objectives
- 3 Letters of Recommendation
- Graduate Record Examination (GRE) scores on the quantitative and analytical portions of the general examination

For international students, a score of 6 on the International English Language Testing System (IELTS) examination, or a minimum score of 213 (CBT)/ 79(IBT) on the Test of English as a Foreign Language (TOEFL), will be required.
Advisors and Dissertation Committees

Upon admission to the program, each student will be nominally assigned to one of the three focus areas based upon interest and background. The Focus Area Chair, as described in Section 3, will become the student’s nominal advisor. Together, they will construct an initial plan of study. Once the student has selected a dissertation advisor, perhaps from a different focus area, that faculty member will become the student’s settled academic advisor.

As soon as possible, students will select a thesis advisor and a dissertation topic motivated by a physical problem. A dissertation committee will be formed consisting of program faculty from at least two CoSM departments, including the thesis advisor, an external committee member who is a WSU faculty person from a college other than CoSM such as CECS, and an appropriately chosen scientist external to WSU. During Year 2 of the program, students will complete advanced coursework in their chosen area of specialization and prepare for a qualifying examination to be administered by the dissertation committee at the end of Year 2. Upon successfully completing the qualifying examination, Ph.D. candidates will concentrate on dissertation research.

The dissertation research is the culmination of the program, requiring originality, persistence and thorough knowledge of the student’s discipline. Students must pose and solve a novel scientific problem, appropriate for their chosen Focus Area, requiring focused thinking and expert analysis. High standards will be imposed. The research should at least be publishable in first rate refereed journals or conference proceedings.

A sample program timeline for student progression in the IASM program is included as Appendix E. As with the previously shown programs of study, it should be noted that this is an idealized program that will vary with students’ backgrounds and abilities.

Program Examinations -- M.S./Ph.D. Qualifying Examinations

IASM students will typically take the M.S./Ph.D. Qualifying Exams following the end of the 2nd semester of their 2nd year in the program. These examinations will be comprised of three separate 90 minute written examinations over the content of the following courses:

- Exam #1 - Mathematical Modeling (MTH 6060) and Scientific Computation (MTH 6150)
- Exam #2 - This will exam will cover a 2- course sequence taken by the student as chosen in consultation with the student’s advisor.
- Exam #3 – The third exam will consist of a 2nd year 2-course sequence chosen in consultation with the student’s advisor.

The examinations may be taken at most twice and will be graded as “Failing,” “Satisfactory,” or “Excellent.” Satisfactory exam performance will entitle students to obtain the ISAM M.S. degree described later. Excellent performance will allow students to advance in the IASM program and work toward developing a Ph.D. dissertation research proposal. It is permissible that IASM students can elect to substitute a portion of the qualifying examinations with a written research thesis and defense. The thesis and defense must be of a level of quality and rigor appropriate for a master’s thesis. This substitution of a master’s thesis for a portion of the qualifying examinations can only be approved at the discretion of the IASM Program Director.
The IASM Ph.D. Candidacy Examination is an oral examination administered by the candidate's Dissertation Committee in which the student defends his or her carefully written dissertation research proposal. The purpose of the Candidacy Examination is to test the validity of the dissertation research proposal and the candidate's fitness to carry out the research work proposed. The examination may be taken no earlier than the semester after the candidate completes the core course work as required by the candidate’s focus area. The candidate must be in good standing with the Graduate School, have the approval of the thesis advisor, and have received an excellent grade on the Qualifying Examinations.

The candidate is required to complete and submit a Request for Candidacy Examination Form to the Program Coordinator at least 30 days before the scheduled defense which must be signed by both the dissertation advisor and Program Director. The format of the proposal will conform to the regulations outlined by the Wright State University Graduate School in the Graduate Policy and Procedures Manual. The substance of the research proposal will form a major part of the oral portion of the exam. As such, it must be a complete document with a thoughtful, in-depth treatment of the dissertation topic. It will be substantial enough to form the basis of a meaningful oral examination, establishing a worthy research problem and developing an effective research plan. It can only be written after the student has done enough preliminary work on the problem to speak meaningfully about it, including discussion of the preliminary investigations. Above all, it will be a technically sound and scholarly document. At least two weeks prior to the scheduled defense, the Research Proposal will be submitted to the candidate's Dissertation Committee.

On the day of the research proposal defense, the examination will begin with a short presentation by the candidate outlining the problem chosen, the procedures and methods to be used, the work already completed, and the additional work proposed to be completed for the Ph.D. degree. The Dissertation Committee will then question the candidate. The committee will also ask questions of a more general nature in order to test the adequacy of the candidate's preparation for the proposed research. At the conclusion of the examination, the dissertation advisor will announce one of four possible decisions:

1. The candidate passed the Candidacy Examination and may proceed to independent study and research for the doctoral degree.
2. The examination is temporarily adjourned. The candidate must revise the Research Proposal and can be examined again within the next six months. The candidate, at this point, has only one remaining change to pass the Candidacy Examination.
3. The candidate failed, but may submit a new Research Proposal and submit to another Candidacy Exam after completing additional course work, independent study, or research. The candidate, at this point, has only one remaining change to pass the Candidacy Examination.
4. The candidate failed and will not be readmitted to another examination.

Members of the Dissertation Committee will sign a Candidacy Exam Evaluation Form with a copy of the signed form given to the student and dissertation advisor.
Ph.D. Dissertation and Defense

Upon conclusion of the research program proposed in the candidacy examination proposal, the student will assemble research results and prepare a written thesis dissertation. A date will be selected for the formal defense of the dissertation following the thesis advisor’s decision that the student is ready to finalize the thesis document and submit it to his or her committee for review. The actual dissertation defense cannot take place any earlier than 6 months after the student passes of the Candidacy Examination. Two weeks before the defense date, the candidate will provide a copy of the dissertation to each dissertation committee member.

On the date chosen, the candidate will give a formal oral presentation of the research results and dissertation analysis before the students’ assembled dissertation committee and a general audience. Following the presentation, the committee shall have ample time to question the candidate regarding the dissertation and may choose to dismiss the general audience. Following this, the student shall be asked to leave the room, and the committee will deliberate. A formal vote will record the committee's decision regarding awarding the candidate the Ph.D. degree. The committee will also provide the Ph.D. candidate with any corrections or editing that will need to be done prior to the submission of the final version of the thesis to the Graduate School and to OhioLink.

If the committee recommends against awarding the degree, it will provide the student with a written explanation of its decision and a recommendation as to how dissertation deficiencies may be corrected. The timeline and procedure for the student to respond to these deficiencies will be assigned by the thesis advisor, but must be approved by the IASM Program Director and be in accordance with the guidelines and policies set by the Graduate School.

Master’s Degree (M.S.) in Interdisciplinary Applied Sciences and Mathematics

Students admitted with the Bachelor’s degree, after completing initial program coursework as described below, and having successfully passed the Qualifying Examinations, will be awarded the Master’s Degree in Interdisciplinary Applied Science and Mathematics. To be awarded the IASM M.S. degree, candidates for the degree must:

1. Complete Ph.D. Core and Focus Area course requirements (a minimum of 30 semester credit hours of course work).
2. Receive at least a satisfactory grade on the Qualifying Examination.
3. Meet the degree requirements of the Graduate School.
3. Program Administration

IASM Program Administration

The administrative home for the IASM program will be in the College of Science and Mathematics. This is appropriate as the intellectual foundations of the fields to be studies are drawn from mathematics and the physical and biological sciences. Initially, administrative support responsibilities and tasks will be shared by staff from the Departments of Mathematics and Statistics and Physics. The organization and administrative structure of the IASM program is as follows.

IASM Program Director

The IASM Ph.D. program will be overseen by a Director reporting to the Dean of the College of Science and Mathematics (CoSM). The Director shall be a tenured faculty member in good standing of a department within CoSM. He or she will be responsible for day to day operations of the program. The Director will review IASM student admission applications and make admission recommendations to the Executive Committee as described below. The Director will also be responsible for oversight of student examinations, reporting, ongoing program evaluation, External Advisory Board involvement, degree certifications, policy modifications, and maintaining high program standards. Finally, the IASM Program Director will coordinate the program’s recruitment efforts associated with not only future students, but also bringing in new faculty to the program. It is important to note as well that the Program Director will also seek to bring in new resources to the IASM program such as research opportunities for students at the nearby Air Force Research Laboratory at WPAFB or external funding from entities such as the National Science Foundation.

IASM Committee Structure

The management and direction of the IASM program will be administered by an organization composed of 3 types of committees. Each committee will consist of IASM program faculty who are tenured or tenure track faculty members from a Wright State University academic unit. The titles and functions of each of the different committees are described below.

1. Focus Area Committees: Each IASM Focus Area will have a 3 member committee led by a Chair to oversee focus area student and curriculum matters.

2. Program Executive Committee: The committee will consist of the Program Director, the 3 Focus Area Committee Chairs, and an Associate Dean of CoSM as an ex-officio member. The committee will be responsible for approving admission recommendations made by the Program Director, approving student plans of study, approving qualifier examinations and coordinating their administration, and approving Dissertation Committees. This committee will also develop protocol associated with the selection and review of IASM program faculty, and design and assess periodic program reviews.

3. Dissertation Committees: The committee will consist of two program faculty from the student’s focus area, one faculty from a second focus area, and one WSU faculty from a WSU
college other than CoSM OR a representative from a nearby institution such as the Air Force Research Laboratory, the Air Force Institute of Technology, or the University of Dayton.

4. **IASM External Advisory Board (EAB):** The IASM Program will also seek advice and guidance from an External Advisory Board. The IASM Program Director will prepare an annual report to be delivered to the EAB at the beginning of each academic year. The EAB will also work with the Program Executive Committee to conduct periodic reviews of the status, health, and direction of the IASM program. EAB members are expected to hold a Ph.D. in a discipline commensurate with the IASM program focus. The Board will be comprised of representatives from organizations external to WSU with vested interests in the program and will provide advice and practical direction to the program. Members of the EAB will nominally consist of the following persons:

1. University of Dayton Dean or Department Chair.
2. Air Force Institute of Technology Dean or Department Chair
3. Air Force Research Laboratory Representative
4. Air Force Research Laboratory Representative
5. Local/Regional Industry Representative
6. Local/Regional Industry Representative
7. Alumnus from WSU Physics or Mathematics B.S. program who received a Ph.D. from another institution
8. Alumnus from WSU Physics or Mathematics B.S. program who received a Ph.D. from another institution

As of January 23, 2014, the following individuals have accepted invitations to join the IASM EAB if the program is approved and instituted. Letters of support from these individuals are attached as Appendix H.

- Dr. Heidi R. Reis, Professor of Physics and Dean for Research, Research and Sponsored Programs, Air Force Institute of Technology
- Dr. Larry R. Dosser, Senior Fellow for Technology Advancement, Center for Manufacturing Sciences, Wright State Research Institute
- Dr. Morley O. Stone, Chief Scientist, 711th Human Performance Wing, Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio
- Dr. Ruth Pachter, Senior Scientist, Computational Materials Science and Engineering, Materials and Manufacturing Directorate, Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio
- Dr. Paul Eloie, Director of Graduate Programs, Department of Mathematics, University of Dayton, Dayton, OH 45469.
4. Need

**Local/Regional/National Need**

Ph.D.-trained individuals in STEM fields are essential for the nation’s economic vitality. The state of Ohio is committed to encouraging high tech industries to flourish. Federal and state governments envisage a continuing transformation to an information-based society in which highly skilled jobs will abound. The Dayton area, already a regional hub for technology, is ideally positioned for continued growth in both pure and applied research. WPAFB is the largest regional high tech employer and the area surrounding the base hosts a variety of high tech firms that provide the USAF with technological expertise. Graduates of the proposed Ph.D. program should readily find employment in the Dayton region and throughout the state, as well as being in demand nationally or globally. Ohio does not currently have a similar interdisciplinary doctoral program in applied science and mathematics. Local support and need for the proposed IASM program is evidenced by the presence of representatives from the Air Force Research Laboratory who have agreed to support the proposed program through service on the program’s External Advisory Board.

Sophisticated technologies will need to be developed in order to confront the great social, economic and environmental challenges of our day: energy production, global warming, medical demands of an aging population, crumbling infrastructure, food security, defense, transportation, and internet bandwidth adequacy and security. Science and technology must play prominent roles in solutions to these daunting problems. The nation will require a highly trained and broadly knowledgeable workforce to realize success. Additionally, those with M.S. and Ph.D. degrees should enjoy increasingly better employment opportunities. The Dayton region will play a prominent role in addressing the nation’s complex problems and technology needs. Graduates of the proposed interdisciplinary Ph.D. program will possess the skills needed to address these vital economic, defense and social concerns. Wright State University is committed to supporting the growth of local industry through the advancement of graduate science and engineering programs. Currently, there are no other state programs that train students as proposed here.

**Student Interest, Demand, & Institutional Need**

As faculty from the Departments of Physics and Mathematics and Statistics form the foundation for the proposed IASM program, and students will primarily be recruited who have math and physics backgrounds, it is appropriate to describe the current graduate programs offered at Wright State University in both these departments. Currently, the WSU Department of Physics offers a M.S. program in Physics with a required thesis project. The Department of Physics also offers a combined dual-degree program, which allows a student to earn both a B.S. in Physics and M.S. in Physics degrees in 5 years. In the Fall of 2013, there were 15 students enrolled in the M.S. program in Physics. Historically, while half of this student population is comprised of full-time students, there is always a significant percentage of part-time students. Many of these part-time students are full-time employees at the Air Force Research Laboratory or a supporting contracting company who are returning to school to further their scientific educations. The WSU Department of Mathematics and Statistics hosts Master’s programs in Mathematics, Applied Mathematics, and Applied Statistics. As is the case with the Physics Department, students who
wish to pursue both a Bachelor's degree and a Master’s degree in Mathematics, Applied Mathematics or Statistics can choose to complete a combined Bachelor of Science and Master of Science degree in 5 years. In the Fall of 2013, there were 10 students enrolled across the M.S. programs in Mathematics and 33 students enrolled in the graduate Applied Statistics (M.S.) program.

While the numbers of undergraduate majors in both departments are small compared to other programs within the College of Science and Mathematics, 95 and 57 in the Fall of 2013 respectively for Mathematics and Physics, there is a history of graduates from both of these undergraduate programs pursuing graduate degrees in their respective fields at Wright State University. Other undergraduate students, in the past, have moved on to graduate programs at Harvard, Cornell, and the University of Wisconsin to name a few. Given these undergraduate students who advance to the existing Master’s programs at WSU in addition to students who come to Wright State University from elsewhere to pursue graduate studies in these departments, it is evident that there is student interest in graduate research and education in mathematics and physics. As many of these students work with the Air Force Research Laboratory or hope to in the future, there is much interest in applied research as well as gaining the appropriate education to conduct such research. Both undergraduate and graduate students in these two departments often express disappointment in the complete lack of any Ph.D. programs in their respective departments. These undergraduate and Master’s students represent great potential as the basis for an interdisciplinary Ph.D. program that is well suited for both their academic and research backgrounds as well as for addressing societal needs.

Hanover Research Feasibility Study

The College of Science and Mathematics at Wright State University commissioned the Hanover Research Corporation to conduct a feasibility study assessing the potential student demand and need for the proposed IASM Ph.D. program. The full study is provided is included Appendix I. This section summarizes the findings of the feasibility study. Specific details, references, and supporting data can be found in the full study. In general, the indicators of demand for the proposed IASM program which included degree conferral trends and long-term employment projections, were positive. The following key findings emerged from the feasibility study:

- **With its proposed program, Wright State stands to take advantage of the lack of competing applied science and mathematics programs and fill an unmet need in the higher education landscape.** Few, if any, programs in applied science and mathematics identical to the program proposed by Wright State University currently exist. Current Ph.D. programs in applied mathematics or applied sciences generally encourage students to concentrate on a single scientific field rather than require study across multiple scientific disciplines. Additionally, the literature indicates that an interdisciplinary approach to scientific research will be increasingly important to innovation in the United States.

- **Applied mathematicians and scientists can expect to see employment opportunities increase over the course of the decade from 2010 to 2020.** The U.S. Bureau of Labor Statistics projects that job prospects will be best for biomedical engineers, biochemists and biophysicists, and environmental engineers. In Ohio, employers are projected to need 366 qualified science- and math-trained individuals to meet labor demand each year.
There is a steadily increasing supply of bachelor’s and master’s students in science and math fields to populate a new doctoral program. Growth in doctoral conferrals in Ohio and neighboring states indicates demand for science and math programs in the area. In Ohio, students have shown particular interest in engineering-related doctoral programs, though growth in conferrals is strongest in mathematics.

Demand for programs in applied mathematics and science—especially in biomathematics, bioinformatics, and computational biology—is increasing at the national, regional, and state levels. While participation in such programs is low in Ohio, this is more likely due to a shortage of area institutions offering doctoral programs, rather than reflective of low student interest. Data reveal a clear sustained interest in applied science and mathematics fields from 2008 to 2012.

An aging workforce presents significant opportunities for graduates of an applied science and mathematics program, nationally and locally. Although occupations of interest are slated to shrink in size over the next several years in Dayton, area employers will require approximately 133 new qualified employees trained in science and mathematics each year through 2018. Slow rates of growth across most occupations are still associated with high levels of annual job openings.

The U.S. government provides substantial funding for interdisciplinary and applied science programs in the form of the National Science Foundation, the National Institutes of Health, and the National Institute of Standards and Technology grants. Academic programs may also seek funding through strategic partnerships with local industries or government facilities within the local geographic region, or national foundations interested in funding STEM programming and research.

Applied Science and Mathematics Programs at Other Institutions

As stated previously, no academic institution in the state of Ohio currently hosts a program similar to the proposed IASM Ph.D. program. While there are multiple public and private universities in Ohio that offer traditional Ph.D. programs in physics and/or mathematics, none of them require coursework or programming exhibiting the highly interdisciplinary nature of the proposed program. It is important to note certain unique aspects of the proposed IASM program here as well. The Introduction to Research year-long course sequence that will provide students with experiential learning in research methods and ethics is unique to Ph.D. programs in the physical sciences.

The lack of programs in Ohio similar to the proposed IASM program should not be taken as a sign that there is no need or relevance for such Ph.D. programs. Major research universities nationwide have had existing interdisciplinary programs in Applied Physics and Applied Mathematics for a long time. In fact, the Hanover Research feasibility study found several institutions that have Ph.D. programs in place that are similar in nature and scope to the proposed IASM degree. These Ph.D. programs include:

- The University of Maryland - Applied Mathematics and Statistics, and Scientific Computation
- The College of William and Mary - Applied Science
- The University of Pennsylvania - Applied Mathematics and Computational Science
• Northwestern University - Applied Mathematics
• Columbia University - Applied Mathematics
• The University of California, Berkeley - Applied Science and Technology.

The Applied Mathematics and Statistics, and Scientific Computation (AMSC) program at the University of Maryland has maintained a consistent level of student participation over the past five years, averaging 88 students per year. The graduate program in Applied Science at the College of William and Mary is interdisciplinary by nature and has approximately 50 graduate students (M.S. or Ph.D.) currently pursuing degrees. The Northwestern University program in Engineering Sciences and Applied Mathematics leads to a Ph.D. degree in advanced applied mathematics. Northwestern admits approximately 10 students every year to this program, and has realized sustained enrollment in its doctoral program; in fact, the program has actually grown over the past decade. Over the past 10 years, 68 percent of the graduates from the Northwestern program went on to postdoctoral research or additional training, 21 percent went directly into academic work, 6 percent worked in industry, and 4 percent worked in the government or non-profit sector. Based on these strong enrollment numbers in similar interdisciplinary Ph.D. programs at major research universities, it is evident that there is strong interest on the part of students in gaining Ph.D. degrees from programs along the lines of that proposed for the IASM program. Finally, it is important to again note that several of these programs have demonstrated sustainable enrollment or even growth over long time periods providing further evidence of the need and relevance of the IASM program at WSU.

Interdisciplinary Research

While IASM program faculty will be recruited from multiple departments across the university, it is important to profile the research scholarship associated with the Departments of Physics and Mathematics and Statistics as it speaks to the feasibility of the IASM program. As can be seen in Section 7, as well as the faculty biographies in Appendix G, the program faculty for the proposed IASM degree program have demonstrated a record of both research publication and funding. Program faculty have currently, or in the past, received funding support from the National Science Foundation, the Air Force Office of Scientific Research, and the National Security Agency to name a few. This record of both scholarly publication as well as research funding not only demonstrates that potential IASM students will have a breadth of research topics to choose from and also support, but conversely it also shows that there is a need for quality Ph.D. students to support these research activities.
5. Prospective Enrollment

Undergraduate and graduate degree programs within CoSM will serve as natural conduits for student recruitment. These include B.S. and M.S. programs in Applied Mathematics, Mathematics, Biostatistics, Biological Sciences, Physics and Applied Statistics. Students from these programs are natural candidates for the IASM Ph.D. program. With regional advertising, it will be possible to attract and recruit students from WSU’s general surrounding area and students from outside of the Dayton area. In addition, as is the case with existing Master’s degree programs in CoSM, the workforce associated with the Air Force Research Laboratory offers a key pool for potential recruitment of students as these workers often seek to advance their educations in local venues.

Initially, a maximum of 5 Ph.D. students will be accepted into the IASM program each year. Given that students will require approximately 5 years to graduate and student attrition is inevitable, it is projected that there will be approximately 25 to 30 students in the program by year 6. Future growth in program faculty as supported by external funding may lead to an increase in program size.

6. Access and Retention of Underrepresented Groups

Women, ethnic minorities and people with disabilities remain significantly underrepresented in the STEM (Science, Technology, Engineering, and Mathematics) disciplines. Within CoSM and WSU, several successful programs have been directed toward attracting traditionally underrepresented groups. WSU has programs aimed at providing research experience for high school students and undergraduates from ethnic minorities. Recent U.S. Department of Education and NSF grant funding has supported minority graduate students and the development of a laboratory curriculum for students with disabilities. WSU has a demonstrated commitment to multiculturalism through designated centers and programming. It enjoys a national reputation for disability services. The campus was constructed to be architecturally barrier free and has an Office of Disability Services that provides service to over 500 students with disabilities. WSU is a founding member of The LEADER Consortium, funded in part by the National Science Foundation ADVANCE Program. This consortium is a partnership of four diverse institutions of higher education in the Dayton area: the Air Force Institute of Technology, Central State University, University of Dayton, and Wright State University. Launched publicly in November 2008, the LEADER Consortium is a member of the fourth cohort of ADVANCE award recipients and is the first of its kind in the ADVANCE Program. Together, these partners aim to identify, research, and implement best practices to increase the recruitment, advancement, and retention of tenure-track women faculty in STEM.
7. Program Faculty and Facilities

Program faculty will be drawn primarily from two CoSM departments, the Department of Mathematics and Statistics and the Department of Physics. The program faculty members have strong research programs that will ensure the success of the new doctoral program. Currently there are 24 Program Faculty members from MTH/STT and Physics, with an additional 9 members from Biology, Earth and Environmental Sciences and Psychology. With likely retirements and CoSM cluster hiring plans, we anticipate the hiring of additional program faculty members in the next two years. In addition, The Endowed Chair in Physics “THz Sensor Physics,” held by Elliot Brown, is endowed by both funds from the Ohio Board of Regents and WSU and provides a critical component of the foundation for the proposed program.

Faculty in the Department of Mathematics and Statistics engage in basic and applied research, and possess expertise in a wide variety of applied science areas. Applied mathematics research areas include optimal control theory, shape optimization, inverse problems, electromagnetic scattering and tomography, the control of fluid flows in aeronautics, stability analysis for dynamic systems, structural and control optimization, numerical linear algebra, and the numerical solution of partial differential equations. Classically oriented mathematics research areas include partial differential equations, discrete mathematics and combinatorics, operator theory, industrial mathematics, harmonic analysis, coding theory, operator algebras, fractals, graph theory, Fourier analysis, and probability theory including stochastic processes. Applied statistics research areas include categorical data analysis, causal inference, clinical trials, mixture models, the design and analysis of experiments, functional and longitudinal data analysis, hierarchical Bayesian models, multiple comparisons, multivariate statistics, nonparametric statistics, quality control, sampling design, survival analysis and efficacy studies. Faculty have engaged in interdisciplinary projects with CoSM faculty in hydrology using partial differential equations to model ground water diffusion, in tomographic imaging of subsurface geology, and NMR imaging using optimal control theory. Faculty have held summer appointments at WPAFB and NASA Glenn Research Center. In addition, the Statistical Consulting Center (est. 1982) is available as a university resource to aid researchers with their statistical needs.

The Department of Physics is involved in 3 major “clusters” of research: Materials Science, Terahertz science and technology, and Physical Modeling and Computational Research.

The Materials Science Research Cluster includes several faculty involved in novel materials research, including chemical synthesis and growth (pulsed laser deposition and sputtering) as well as the characterization of the electrical, microfluidic, optical, magnetic and thermal properties of these materials. Device physics studies include transport processes and nano-enhanced functional characteristics of materials such as multiferroics, carbon nanotubes and peptide nanowires, graphene, nitride semiconductors, zinc oxide, photorefractive materials, and DNA biopolymers. Instrumentation for the study of these materials include UV-VIS-IR-THz-microwave spectrometers, atomic force microscopes, evanescent microwave microscopy, particle accelerators (electron and proton Van de Graaf and an ion implanter) for the study of defects, a Hall effect measurement system, and a deep level transient spectroscopy system. For nanoscience research, a variety of nano-profilometric and diagnostic tools including evanescent microwave microscopy and atomic force microscopy are available. The spectroscopy groups are equipped with high-resolution spectrometers and detection systems that include photographic.
intensified CCD, and photon counting systems. Several laser sources are available, including a six-watt argon ion laser, a nitrogen laser, a pulsed dye laser, diode lasers, and pulsed ultrafast lasers.

The Terahertz Collaborative Research Cluster explores basic THz phenomenology for sensing and imaging applications including the study of the vibrational resonances of biomolecules in breath analysis (medical diagnostics), environmental monitoring, and biometric signatures. Electromagnetic propagation studies include multi-scale scattering, inverse problems, plasmonic waveguides, and transient signatures associated with sensing and imaging applications. Materials studies include ultrafast photoconductive investigations of metal-semiconductor nanocomposites and the study of the THz optical properties of novel materials. Computational research includes multi-physics and full-wave electromagnetic studies of components for THz system development, such as for plasmonic devices. Technologies available include electronic frequency multiplication systems, femtosecond laser based time-domain-spectroscopy and imaging, difference frequency generation system, imaging gantries, heterodyne radar systems, and test instrumentation. All together, the Terahertz cluster consists of over 5000 square feet of laboratory space which includes radar, spectroscopy, and imaging systems for the study and development of non-destructive sensing techniques and applications.

The Physical Modeling and Computational Research Cluster studies a broad range of topics such as flow transport processes in random systems, percolation theory applied to geophysical processes, NMR applications using optical control theory, space physics and aeronomy research, and modeling of planetary atmospheres. Other areas of ongoing research activity include nonlinear systems analysis, scaling, self-similar criticality, complexity in geophysics, modeling of seismic activity, bioinformatics, and modeling of biochemical processes. This group utilizes several workstations with computer support services provided through the University’s Computing and Telecommunication Services. Faculty conducting computational research also utilize the Ohio Supercomputing Center. In addition, the Terahertz Sensors Group, led by Dr. Elliott Brown, possesses a 252 core computing cluster.

Other facilities within the College of Science and Mathematics, other WSU organizations, and local entities situated off-campus exist that will support the IASM program. Additional on-campus facilities include an x-ray diffraction system, a mass spectrometer, nuclear magnetic resonance apparatus, and a Zeiss electron microscope. There is also a departmental machine shop along with staffed machine and electronics shops.

Strategic partnerships with off-campus organizations and companies will also broaden the scope of scientific facilities available for IASM affiliated research work. IASM program faculty have long standing research collaborations with several directors at the WPAFB Air Force Research Laboratory including Sensors, Materials and Manufacturing, Aerospace Systems, and Human Performance as well as the Air Force Institute of Technology. The concentration of AFRL resources has also led to the presence of several R&D companies such as UES and Mound Laser and Photonics, Inc., both of which have a significant history of working with multiple IASM program faculty members. These off-campus R&D facilities not only offer incredible research opportunities for IASM dissertation work, but also are appropriate for the interdisciplinary and applied nature of the proposed Ph.D. program.
The IASM Program faculty have generated more than $15 million in extramural funding during the past 6 years. A number of IASM program faculty involved in the program are nationally and internationally recognized for strong research programs. Brief descriptions of selected IASM program faculty are included below. Each faculty description includes an approximate total, in parentheses, of extramural funding for the previous 6 years.

Dr. Yi Li, Dean of the College of Science and Mathematics and Professor of Mathematics, He has held faculty positions at the University of Chicago, the University of Rochester, and the University of Iowa where he served as mathematics department chair. He is an internationally known mathematician with research interests in studies of nonlinear partial differential equations and their applications in physics, geometry, and biomedical research. He has published more than 70 peer-reviewed publications, with his work supported by NSF and NIH.

Dr. Weifu Fang, Professor of Mathematics and Department of Mathematics and Statistics Chair, works in the areas of applied and computational math, partial differential equations, and inverse problems. Most of his research projects originated from applications such as semiconductor modeling, nondestructive testing techniques, and tomography.

Dr. K.T. Arasu, Professor of Mathematics, works in the areas of Discrete Mathematics, Cryptography & Data Security, Algebraic and number theoretic methods in Combinatorics. His work has been supported for 25 years by NSF, AFOSR and NSA (over $1.5 million in extramural funding). At WSU he has been awarded the Presidential Research Excellence Award and the Trustee’s Award for Faculty Excellence.

Dr. Qingbo Huang, Professor of Mathematics, is a well-known mathematician with research interests in nonlinear partial differential equations and real harmonic analysis. His research interests include convex analysis and geometry, and geometric optics, including equations of Monge-Ampere type, fully nonlinear elliptic equations, reflector and refractor problems, optimal mass transport, and elliptic systems. ($137,842 in extramural funding)

Dr. Harry Khamis, is Director of the Statistical Consulting Center and Professor of Mathematics & Statistics and of Community Health (Boonshoft School of Medicine – joint appointment). He has published extensively in the areas of categorical response models, the Cox regression model, and Goodness of Fit tests, and has supervised two statistics Ph.D. students. (Nearly $1 million in external funding)

Dr. Gengxin Li, Assistant Professor of Statistics, works in the area of biostatistics focusing on developing new statistical methodologies and efficient computational tools to extract maximum information from complex biological systems. works in Bioinformatics and Biostatistics. Her research interests include statistical genomics and genetics, bioinformatics, hierarchical models, functional/longitudinal data analysis and large scale and high-dimensional data analysis.

Dr. Qun Li, Assistant Professor of Mathematics, has research interests concentrated in geometric analysis and partial differential equations. Her work is currently supported by a three year NSF grant.
Dr. Steen Pedersen, Professor of Mathematics, has held faculty positions at Aarhus University, the University of Iowa, and IUPUI. He works generally in the area of operator theory with special interests in fractals, metric geometry, Fourier analysis, spectral theory, and operator algebras. ($94,000 in extramural funding.)

Dr. Dan Slilaty, Associate Professor of Mathematics, works in algebraic and topological approaches to graph theory and matroid theory. Much of his research is theoretical but applications can be found in linear and integer optimization, network flows, and the geometric structure of fullerene molecules and other molecules. ($35,000 in extramural funding)

Dr. Mohamed Sulman, Assistant Professor of Mathematics, works in applied and computational methods for nonlinear partial differential equations. He studies transport and mixing problems has research interests in in 3D Ocean, adaptive grid methods for solving time-dependent partial differential equations, computational fluid dynamics, optimal mass transport problem, and medical image computing.

Dr. Thaddeus Tarpey, Professor of Statistics, works in the area of multivariate statistics. He is a Fellow of the American Statistical Association and has published extensively in biostatistics with particular interest in functional data analysis with applications to mental health research. ($706,217 in extramural funding)

Dr. Weizhen Wang, Professor of Statistics and Director of Statistics Program, has research interests in bioequivalence, dose-response studies, clinical trials, saturated designs and adaptive designs, categorical data analysis and exact statistical inferences. He proposed optimal exact confidence intervals for many functions of proportions, including difference, risk and odds ratios, and implemented computations in R programs. Recently he showed the failure of ALL bootstrap confidence intervals for proportions for ANY sample size. ($189,872 in extramural funding)

Dr. Douglas Petkie, Associate Professor and Department Chair of Physics, currently has research interests including molecular spectroscopy and terahertz imaging and spectroscopy. He has generated over $5M in external funding and has a patent pending. He also does research on micro-Doppler radar signatures (sensing vital signs and gait) as well as electromagnetic non-Destructive evaluation (NDE) imaging. ($6,500,000 in extramural funding)

Dr. Elliott Brown, Professor of Physics and Electrical Engineering, worked at the Hughes Aircraft Co. and MIT Lincoln Laboratory, and was a program manager for DARPA. Before joining WSU in 2010, he was an EE faculty at UCLA and an ECE professor at UCSB. Dr. Brown is a Fellow of the IEEE and of the American Physical Society. In 1998, he received an Award for Outstanding Achievement from the U.S. Office of the Secretary of Defense. He is the Ohio Research Scholar (Endowed Chair) in Layered Sensing at WSU. His research includes terahertz solid state electronic devices and has been funded by the NSF and the DoD. This research in solid-state sensor devices involves all aspects of device analysis and design including the basic solid-state physics, optimal sensor geometry and coupling, noise mechanisms, and readout electronics. ($1,300,000 in extramural funding)
Dr. Jason Deibel, Associate Professor of Physics, got his PhD in applied physics working on ultrafast spectroscopy. His current research focuses on the design and application of terahertz (THz) systems, including the finite-element simulation of THz waveguides and metamaterials, and the THz characterization of novel materials such as carbon nanotubes and composite materials. ($4,700,000 in extramural funding)

Dr. Gary Farlow, Associate Professor of Physics, works in radiation damage, radiation processing and radiation related analysis techniques in solids. He has analyzed thermodynamic constraints on ion beam mixing involving insulators, analyzed precipitation processes in ion-implanted insulators, developed an analytical technique for Rutherford backscattering analysis of mixed phase layers, and developed low temperature, electron damage techniques for study of GaN and ZnO. ($21,000 in extramural funding)

Dr. Brent Foy, Associate Professor of Physics, has a background in Medical Physics. His research interests include: developing biologically-based kinetic models of toxin disposition; performing bioinformatic support and modeling for genomics/proteomics/metabolomics studies; studying diffusion of proteins in cartilage as a possible sensitive indicator of early arthritic decay; using 13C NMR and mathematical models of biochemical reaction pathways to estimate metabolic fluxes.

Dr. Allen Hunt, Professor of Physics, received his PhD in Condensed Matter Theory and was a Fulbright Fellow at Philipps Universitaet Marburg, 1985-1987. He was Hydrologic Sciences program director at NSF 2002-2003 and has been visiting faculty and scientist at a number of institutions before joining Wright State in 2004. His current research focuses on transport in porous media. He has given numerous invited talks on that subject at international conferences and recently wrote Percolation Theory for Flow in Porous Media, 2nd ed. (2009) by Springer Verlag. Dr. Hunt has a joint appointment with the Department of Earth & Environmental Sciences. ($219,000 in extramural funding)

Dr. Gregory Kozlowski, Professor of Physics, joined Wright State in 1999 after 10 years working in the Materials Directorate at the Air Force Research Lab, Wright-Patterson AFB. His research interests include materials science, magnetism and superconductivity. He has published over 100 papers and has been awarded a couple of patents. Dr. Kozlowski has a PhD from the Polish Academy of Sciences and a DSc from Wroclaw University. ($238,000 in extramural funding)

Dr. Ivan Medvedev, Assistant Professor of Physics, has research interests that lie in the area of experimental atomic and molecular optical physics, with primary focus being the study of high resolution molecular ro-vibrational spectroscopy and its analytical applications. Currently, he is working on the development of analytical THz sensors in application to environmental and occupational chemical sensing and intelligence. He has over 30 peer-reviewed articles to date. ($147,000 in extramural funding)

Dr. Amit Sharma, Assistant Professor of Physics, works in the field of applied theoretical/computational electronic structure methods with focus on developing fundamental
understanding, investigation of thermochemistry, study of dynamics and kinetics of chemical reactions which are important to understanding combustion. He has also contributed significantly to computational spectroscopy of the gas-phase molecular species.

Dr. Thomas Skinner, Professor of Physics, obtained his PhD in Physics, applying ultraviolet spectroscopy to the study of the outer planets. He has since expanded his research into the field of nuclear magnetic resonance (NMR) spectroscopy. He joined the Wright State Physics Department in 1993 and has received funding from NSF, NASA, and NIH. His primary research is the development of advanced NMR and EPR methods for spectroscopy and imaging, with a focus on applications of optimal control theory. He has also received funding for applying percolation theory to groundwater transport, as well as funding for continued research in planetary atmospheres. ($783,000 in extramural funding)

Dr. Sarah Tebbens, Associate Professor of Physics, has a PhD in Marine Geology and Geophysics. She was a tenured faculty at the University of South Florida before joining Wright State in 2004. Her research involves the nonlinear analysis and modeling of geophysical processes including coastal changes, tsunamis, forest fires, seismology and environmental hazards.
8. Additional Needs for Faculty and Facilities

The College of Science and Mathematics at WSU currently hosts Ph.D. programs in Biomedical Sciences, Environmental Science and Human Factors and Industrial/Organizational Psychology. There is an active collection of faculty within CoSM that will provide the core group of Ph.D. program faculty with the necessary expertise to recruit and advise Ph.D. students. Additional program faculty will be hired as retiring CoSM faculty are replaced. New positions will be expected to fill demonstrated areas of need. The existence of the proposed Ph.D. program will play a vital role in hiring new faculty, as current faculty in Mathematics and Statistics and Physics do not have access to Ph.D. students. Start-up costs for new hires will be competitive to attract top-flight researchers. Additional space needs will be partially addressed with the new NEC (Neuroscience and Engineering Collaboration) building. In anticipation of the proposed IASM program, two new tenure-track faculty members, Amit Sharma in Physics and Mohamed Sulman in Mathematics, were recruited and hired in 2013 with the idea that these two new hires would add to the number of program faculty and strengthen the research and academic diversity of the program.

9. Projected Additional Costs and Evidence of Institutional Commitment

It is anticipated by both the Department of Mathematics and Statistics, and the Department of Physics, that there will be considerable faculty turnover in the next 5 years due to retirements. These departments and CoSM are committed to directing new department hires into faculty recruitments in support of the proposed Ph.D. program. The College leadership is promoting cluster hiring strategies within the college, demonstrating its commitment to support interdisciplinary research, an essential ingredient of the Ph.D. program. Students in the program will be supported by a combination of Graduate Teaching Assistantships (GTA) and Graduate Research Assistantships (GRA) funded by faculty advisors’ extramural research contracts. It is also anticipated that a limited number of Fellowships will be awarded through Research Challenge funds. Approximately 6 existing GTA positions in the primary program departments will be directed to Ph.D. students. To maintain a program size of 25 students, 7-8 new GTA positions will be needed by year 5. The college and university are both committed to securing these GTA positions as the program grows.
10. Cited References

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3. The Ohio State University Department of Mathematics, “Doctor of Philosophy (PhD),” https://math.osu.edu/grad/current/phd
5. The University of Wisconsin Department of Mathematics, “Ph.D. Requirements,” http://www.math.wisc.edu/graduate/phd-requirements
8. Wright State University Ph.D. in Engineering Program, “Degree Requirements,” http://cecs.wright.edu/programs/doctoral/engineering/students/current/requirements
Appendix A: Sample Academic Programs of Study

The sample programs here are intended for well-prepared students. Some students may satisfy the required program coursework at a slower pace.

I. Materials and Nanoscale Science and Technology: Sensor theory, biomolecular engineering, transport processes in noncrystalline materials, electromagnetic propagation in inhomogeneous media, spectroscopy, imaging, device physics.

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<thead>
<tr>
<th>Year 1 (24 hours total)</th>
<th>Year 2 (24 hours total)</th>
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<tbody>
<tr>
<td><strong>Semester 1 (12 hours)</strong></td>
<td><strong>Semester 2 (12 hours)</strong></td>
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<tr>
<td>MTH 6060 Mathematical Modeling (Core 3 hours)</td>
<td>MTH 6150 Scientific Computation (Core 3 hours)</td>
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<tr>
<td>MTH 6260 Matrix Computations (FAIII 3 hours)</td>
<td>MTH 6070 Optimization Techniques (FAIII 3 hours)</td>
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<tr>
<td>PHY 6730 Mathematical Physics (FAI 3 hours)</td>
<td>PHY 6830 Statistical Mechanics (FAI 3 hours)</td>
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<td>IASM 8000 Introduction to Research I (3 hours)</td>
<td>IASM 8010 Introduction to Research II (3 hours)</td>
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<th>Year 2 (24 hours total)</th>
<th>Year 3 (12 hours)</th>
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<tr>
<td><strong>Semester 1 (12 hours)</strong></td>
<td><strong>Semester 2 (12 hours)</strong></td>
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<tr>
<td>PHY 6810 Electromagnetic Theory I (FAI 4 hours)</td>
<td>PHY 6820 Electromagnetic Theory II (FAI 4 hours)</td>
</tr>
<tr>
<td>PHY 7100 Quantum Mechanics I (FAI 3 hours)</td>
<td>PHY 7110 Quantum Mechanics II (FAI 3 hours)</td>
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<tr>
<td>IASM 8100 Graduate Seminar (2 hours)</td>
<td>IASM 8100 Graduate Seminar (2 hours)</td>
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<tr>
<td>IASM 8300 Independent Research (3 hours)</td>
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<tr>
<th>Year 3 (12 hours)</th>
<th>Dissertaton Hours (IASM 8400) = 30 hours minimum. Total Hours = 24 +24 + 12 + 30 = 90 hours minimum.</th>
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<tr>
<td>2-4 Electives to be chosen from IASM Focus Area Courses. (See lists below)</td>
<td>IASM 8200 Semester Internship may substitute for up to 2 electives.</td>
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IASM 8300 Independent Research (3 hours)
**II. Modeling and Analysis for Physical and Biological Systems:** Nonlinear dynamics, complexity, transport processes, scattering and sensing, discrete dynamic systems, analysis under uncertainty, modeling of biological systems, biostatistics, cognitive modeling, multi-scale physics.

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<th>Semester 1 (12 hours)</th>
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<td></td>
<td>MTH 6060 Mathematical Modeling (Core 3 hours)</td>
<td>MTH 6150 Scientific Computation (Core 3 hours)</td>
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<td></td>
<td>MTH 6810 Applied Mathematics I (FA 2 3 hours)</td>
<td>MTH 6820 Applied Mathematics II (FA2 3 hours)</td>
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<td></td>
<td>PHY 6710 Mechanics (FAI 3 hours)</td>
<td>PHY 6830 Statistical Mechanics (FAI 3 hours)</td>
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<td>IASM 8000 Introduction to Research I (3 hours)</td>
<td>IASM 8010 Introduction to Research II (3 hours)</td>
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<tr>
<td></td>
<td>MTH 7160 Numerical Analysis I (FAII 4 hours)</td>
<td>MTH 7170 Numerical Analysis II ((FAII 4 hours)</td>
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<td></td>
<td>MTH 7310 Real Analysis I ((FAII 4 hours)</td>
<td>MTH 7320 Real Analysis II ((FAII 4 hours)</td>
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<td>IASM 8100 Graduate Seminar (2 hours)</td>
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<td>IASM 8300 Independent Research (2 hours)</td>
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<td>IASM 8200 Semester Internship may substitute for up to 2 electives.</td>
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III. Computational Problems in the Physical and Biological Sciences: Inverse problems, system optimization, computational statistics, bioinformatics, computational biology, cognitive processing.

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<tr>
<th>Year 1 (24 hours total)</th>
<th>Semester 1 (12 hours)</th>
<th>MTH 6060 Mathematical Modeling (Core 3 hours)</th>
<th>STT 6640 Computational Statistics (FAIII 4 hours)</th>
<th>ES 7120 Environmental Biology: Genes, Organisms and Ecosystems (FAII 3 hours) OR STT 6300 Biostatistics (FAII 3 hours)</th>
<th>IASM 8000 Introduction to Research I (3 hours)</th>
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<tr>
<td>Semester 2 (21 hours)</td>
<td>MTH 6150 Scientific Computation (Core 3 hours)</td>
<td>STT 7670 Applied Regression Analysis (FAIII 4 hours)</td>
<td>BIO 6600 Population Genetics (FAII 3 hours) OR STT 7020 Applied Stochastic Processes (FAII 3 hours)</td>
<td>IASM 8010 Introduction to Research II (3 hours)</td>
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<tr>
<th>Year 2 (24 hours total)</th>
<th>Semester 1 (12 hours)</th>
<th>MTH 7160 Numerical Analysis I (4 hours)</th>
<th>MTH 6070 Optimization Techniques (FAIII 3 hours) OR STT 7670 Applied Regression Analysis FAIII (3 hours)</th>
<th>IASM 8100 Graduate Seminar (2 hours)</th>
<th>IASM 8300 Independent Research (3 hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semester 2 (12 hours)</td>
<td>MTH 7170 Numerical Analysis II (4 hours)</td>
<td>BIO 6600 Population Genetics (FAII 3 hours) OR STT 6640 Computational Statistics (FAIII 4 hours) OR STT 7140 Environmental Statistics (FAII 3 hours)</td>
<td>IASM 8100 Graduate Seminar (2 hours)</td>
<td>IASM 8300 Independent Research (2-3 hours)</td>
<td></td>
</tr>
</tbody>
</table>

| Year 3 (12 hours)      | 2-4 Electives to be chosen from ISAM Focus Area Courses. (See lists below) | IASM 8200 Semester Internship may substitute for up to 2 electives. |

| Dissertation Hours (IASM 8400) = 30 hours minimum. Total Hours = 24 + 24 + 12 + 30 = 90 hours minimum. |
Appendix B: Focus Area Courses

Focus Area I courses (Materials and Nanoscale Science and Technology)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHM 6170</td>
<td>Applied Chemical Spectroscopy</td>
<td>3 hours</td>
</tr>
<tr>
<td>CHM 6680</td>
<td>Experimental Nanomaterials and Nanoscience</td>
<td>3 hours</td>
</tr>
<tr>
<td>ES 7180</td>
<td>Chemical Processes in the Environment</td>
<td>3 hours</td>
</tr>
<tr>
<td>PHY 6400</td>
<td>Nanoscience and Nanotechnology</td>
<td>3 hours</td>
</tr>
<tr>
<td>PHY 6710</td>
<td>Mechanics</td>
<td>3 hours</td>
</tr>
<tr>
<td>PHY 6810</td>
<td>Electromagnetic Theory I</td>
<td>4 hours</td>
</tr>
<tr>
<td>PHY 7110</td>
<td>Quantum Mechanics II</td>
<td>3 hours</td>
</tr>
<tr>
<td>PHY 7540</td>
<td>Topics in Geophysics</td>
<td>3 hours</td>
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</tbody>
</table>

Focus Area II courses (Modeling and Analysis for Physical and Biological Systems)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 6460</td>
<td>Advanced Cell Biology</td>
<td>3 hours</td>
</tr>
<tr>
<td>BMB 7520</td>
<td>Molecular Biochemistry II</td>
<td>3 hours</td>
</tr>
<tr>
<td>BIO 6470</td>
<td>Population and Community Biology</td>
<td>3 hours</td>
</tr>
<tr>
<td>ES 7160</td>
<td>Complexity in Environmental Systems</td>
<td>4 hours</td>
</tr>
<tr>
<td>EES 6160</td>
<td>Stratigraphy and Sedimentation</td>
<td>4 hours</td>
</tr>
<tr>
<td>MTH 6070</td>
<td>Optimization Techniques</td>
<td>3 hours</td>
</tr>
<tr>
<td>MTH 7160</td>
<td>Numerical Analysis I</td>
<td>4 hours</td>
</tr>
<tr>
<td>MTH 7310</td>
<td>Real Analysis I</td>
<td>4 hours</td>
</tr>
<tr>
<td>PHY 6830</td>
<td>Statistical Mechanics</td>
<td>3 hours</td>
</tr>
<tr>
<td>PSY 7050</td>
<td>Cognition</td>
<td>3 hours</td>
</tr>
<tr>
<td>PSY 8090</td>
<td>Computational Cognitive Modeling</td>
<td>3 hours</td>
</tr>
<tr>
<td>STT 6300</td>
<td>Biostatistics</td>
<td>3 hours</td>
</tr>
<tr>
<td>STT 7020</td>
<td>Applied Stochastic Processes</td>
<td>3 hours</td>
</tr>
<tr>
<td>STT 7140</td>
<td>Environmental Statistics</td>
<td>3 hours</td>
</tr>
<tr>
<td>STT 7670</td>
<td>Applied Regression Analysis</td>
<td>3 hours</td>
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</table>
Focus Area III courses (Computational Problems in the Physical and Biological Sciences)

<table>
<thead>
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<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>EES 6210</td>
<td>Structural Geology and Tectonics</td>
<td>4</td>
</tr>
<tr>
<td>EES 6250</td>
<td>Climate Change</td>
<td>3</td>
</tr>
<tr>
<td>MTH 6070</td>
<td>Optimization Techniques</td>
<td>3</td>
</tr>
<tr>
<td>MTH 6260</td>
<td>Matrix Computations</td>
<td>3</td>
</tr>
<tr>
<td>MTH 7160</td>
<td>Numerical Analysis I</td>
<td>4</td>
</tr>
<tr>
<td>MTH 7770</td>
<td>Applied Analysis II</td>
<td>4</td>
</tr>
<tr>
<td>PSY 8110</td>
<td>Applications of Visual Science</td>
<td>3</td>
</tr>
<tr>
<td>PSY 8130</td>
<td>Fundamentals of Motion Detection</td>
<td>3</td>
</tr>
<tr>
<td>STT 6260</td>
<td>Survival Analysis</td>
<td>3</td>
</tr>
<tr>
<td>STT 7140</td>
<td>Stat. Modeling for Env. Data</td>
<td>3</td>
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<tr>
<td>STT 7440</td>
<td>Applied Multivariate Statistics</td>
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</tr>
<tr>
<td>STT 6640</td>
<td>Computational Statistics</td>
<td>3</td>
</tr>
<tr>
<td>STT 7400</td>
<td>Categorical. Data Analysis</td>
<td>3</td>
</tr>
<tr>
<td>STT 7670</td>
<td>Applied Regression Analysis</td>
<td>3</td>
</tr>
</tbody>
</table>

EES 6240 Oceanography (4 hours)
EES 6290 Remote Sensing (3 hours)
MTH 6140 Mathematical Software (3 hours)
MTH 6570 Combinatorics and Graphs (4 hours)
MTH 7170 Numerical Analysis II (4 hours)
PSY 8090 Computational Cognitive Modeling (3 hours)
PSY 8140 Psychoacoustics (3 hours)
STT 6640 Computational Statistics (3 hours)
STT 7400 Categorical. Data Analysis (3 hours)
STT 7670 Applied Regression Analysis (3 hours)
Appendix C: IASM Core Course Syllabi

MTH 6060 Mathematical Modeling

I. College/School        COSM
            Department       MTH-STT

II. Course Information
    Course Title: MTH 6060 Mathematical Modeling
    Credit Hours: 3
    Prerequisites: Admission into the IASM Ph.D. program

III. Course Objectives

    This course will introduce IASM students to the construction and analysis of mathematical models in science and industry.

    Author: Charles R. MacCluer
    Prentice Hall

V. Syllabus

1. Introduction to Modeling.
   What is Modeling?
   Model Construction
   Model Analysis
   Model Validation.
   First Model Examples
   Population Dynamics

2. Statistical Reasoning
   Random Variables.
   Uniform Distributions.
   Gaussian Distributions.
   The Binomial Distribution.
   Taguchi Quality Control.

3. Monte Carlo methods
   Computing integrals
   Mean time between failure (MTBF)
   Servicing requests
   The newsboy problem (reprise)

4. Data Acquisition and Manipulation
   The z-Transform
   Linear Recursions
   Filters
   Stability
   The Fast Fourier Transform
   Polar and Bode Plots
Aliasing

5. **Discrete Fourier transform (DFT)**
   - Realtime processing
   - Properties of the DFT
   - Filter design
   - The fast Fourier transform (FFT)
   - Image processing

6. **Linear Programming**
   - Optimization
   - The Diet Problem
   - The Simplex Algorithm

7. **Regression**
   - Best fit to discrete data
   - Norms on $\mathbb{R}^n$
   - Hilbert space
   - Gram's theorem on regression

8. **Cost Benefit Analysis**
   - Present value
   - Life cycle costing

9. **Microeconomics**
   - Supply and Demand
   - Revenue, Cost and Profit
   - Elasticity of Demand
   - Duoplistic Competition
   - Theory of Production
   - Leontiv Input/Output

10. **Ordinary Differential Equations**
    - Separation of variables
    - Mechanics
    - Linear ODE's with Constant Coefficients
    - Systems of ODE's
    - Control Systems

11. **Frequency domain methods**
    - The frequency domain
    - Generalized signals
    - Stability
    - Filters
    - Feedback and root-locus
    - Nyquist analysis
    - Frequency Domain Control

12. **Partial differential equations**
    - Lumped versus distributed
    - The big six PDEs
Separation of variables
Unbounded spatial domains
Periodic steady state
Other distributed models

13. Divided Differences
Euler's Method
SYstems
PDE's
Runga-Kutta Method

14. Galerkin's method
Galerkin's Approximation
Eigenvalue Problems
Steady Problems
Transient Problems
Finite Elements

15. Splines
CubicSplines
m-Splines_____________________________

This is a course topics syllabus designed for the suggested text above. Course materials, method of instruction, evaluation and policy, grading policy, assignments, and other course matters can differ by specific course sections and individual professors. Additional information can be obtained by contacting the appropriate college and department.
MTH 6150 Scientific Computation

I. College/School     COSM
    Department       MTH-STT

II. Course Information

    Course Title: MTH 6060 Mathematical Modeling
    Credit Hours: 3
    Prerequisites: Admission into the IASM Ph.D. program

II. Course Objectives

    This course considers the modern computational techniques for simulating scientific phenomena. It continues the study of mathematical models begun analytically in MTH 60660 Mathematical Modeling, and extends that analysis to numerical model simulation and validation. Of particular interest will be the use of the computing packages Matlab, Mathematica and Excell to solve modeling equations too complex for hand calculations. Specific models analyzed will be chosen from those studied or constructed in MTH 6060, and will depend upon student and instructor interests and needs.

    Course materials, method of instruction, evaluation and policy, grading policy, assignments, and other course matters can differ by specific course sections and individual professors. Additional information can be obtained by contacting the appropriate college and department.
IASM 8000 Introduction to Research I

I. College/School  COSM  
Department  MATH-STAT & PHYSICS

II. Course Information
   Course Title: IASM Introduction to Research  
   Credit Hours: 3  
   Course Abbreviation and Number:  8000  
   Course Cross Listing(s) Abbreviation and Number:  
   Check (“x”) all applicable:  
   Writing Intensive_____Service Learning_____Laboratory_____Laboratory Grade Separate_____  
   Ohio TAG (Transfer Assurance Guideline) Course_____Ohio Transfer Module Course_____

III. Course Registration
   Prerequisites: Admission into the IASM Ph.D. program  
   Other: permission of the department

IV. Course Objectives
   This course will introduce IASM students to the ongoing research activities within the three focus areas and will include presentations by IASM faculty. It will introduce IASM students to research methods including literature research, data analysis, written presentations, and oral presentations. This course will aid the student in the selection of his/her doctoral research director. It will also consider research ethics which will emphasize the evaluation of hypothetical ethical scenarios in research. Class discussion will be based on integrating ethical policy and practices as they relate to research at Wright State and beyond. The course uses a case-based method to cover various topics related to professional research ethics. This course will also provide students with experience and guidance in scientific writing. For both written reports, students will be required to submit outlines and first drafts prior to submission of the final draft.

VI. Suggested Course Materials (required and recommended)
   • Schimel, J. (2012). Writing science: How to write papers that get cited and proposals that get funded. Oxford: Oxford University Press. (Recommended)

VII. Suggested Method of Instruction - Lecture/Seminar
VIII. Suggested Evaluation and Policy

**Course requirements:**

Attendance – 25% of final grade
Ethical Research Case Study – 25% of final grade
  (outline = 5%, first draft = 5%, final draft = 15%)
Written Research Report – 25% of final grade (outline = 5%, first draft = 5%, final draft = 15%)
Oral Research Presentation – 25% of final grade (outline = 5%, presentation = 20%)

**Course Grading**

A: 90-100%, B: 75-79.9%, C: 60-74.9%, D: 50-59.9%, F: < 50%

All reports and presentations must be on a technical level that is understandable by someone with a general physics and mathematics background, e.g., comparable to a Scientific American or more advanced.

This course is a writing intensive class. Students will be expected to produce writing that
- Demonstrates their understanding of course content,
- Is appropriate for the audience and purpose of a particular writing task,
- Demonstrates the degree of mastery of disciplinary writing conventions appropriate to the course (including documentation conventions), and
- Shows competency in standard edited American English.

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attendance</td>
<td>Students are expected to attend each and every class session. As the class will consist of multiple research presentations, tours, and group work, it is essential that students attend.</td>
</tr>
<tr>
<td>Ethical Case Study</td>
<td>As part of the course’s emphasis on learning and assessing proper ethics in research, student teams will each be given a hypothetical ethics case and be expected to develop a case study analyzing the situation.</td>
</tr>
<tr>
<td>Written Report</td>
<td>Students must complete a minimum 4 page report summarizing the research of an IASM program faculty member in the format of an academic journal article which has been selected by the course instructor. Students will submit drafts of the final report and will receive written feedback from the advisor so that the students may submit a revised final draft.</td>
</tr>
<tr>
<td>Oral Presentation</td>
<td>All students will give a presentation of the written report work to the class near the end of the semester.</td>
</tr>
</tbody>
</table>

This is a course guideline syllabus. Course materials, method of instruction, evaluation and policy, grading policy, assignments, and other course matters may differ by specific course sections and individual professors. Additional information can be obtained by contacting the appropriate college and department.
IASM 8010 Introduction to Research II

I. College/School  COSM
Department  MATH-STAT & PHYSICS

II. Course Information
   Course Title: IASM Introduction to Research
   Credit Hours: 3
   Course Abbreviation and Number:  8010
   Course Cross Listing(s) Abbreviation and Number:
   Check (“x”) all applicable:
   Writing Intensive_____Service Learning_____Laboratory_____Laboratory Grade Separate_____
Ohio TAG (Transfer Assurance Guideline) Course_____Ohio Transfer Module Course_____

III. Course Registration
   Prerequisites:  IASM 8000 Introduction to Research I
   Other: permission of the department

IV. Course Objectives
   This course is a follow-up to IASM Introduction to Research I with the goal of continuing advancing student preparation for thesis research. The second semester of this course will focus on the development of research projects. Students will continue to get exposure to the research activities of program faculty via seminars. In addition, the student activity in the second semester will focus on the development of a “mock” research proposal. Each student will formulate a research question, conduct a literature review, and develop a research methodology and budget. This proposal will be prepared in the form of a written proposal and also defended orally to classmates and a panel of program faculty. This course will also provide students with experience and guidance in scientific writing. For both written reports, students will be required to submit outlines and first drafts prior to submission of the final draft.

VI. Suggested Course Materials (required and recommended)

VII. Suggested Method of Instruction - Lecture/Seminar
VIII. Suggested Evaluation and Policy

**Course requirements:**

- Attendance – 20% of final grade
- Research Proposal Abstract / Summary – 20% of final grade
- Research Proposal Budget – 20% of final grade
- Written Research Proposal – 20% of final grade (outline = 5%, first draft = 5%, final draft = 10%)
- Oral Proposal Presentation – 20% of final grade (outline = 5%, presentation = 15%)

**Course Grading**

A: 90-100%, B: 75-89.9%, C: 60-74.9%, D: 50-59.9%, F: < 50%

All reports and presentations must be on a technical level that is understandable by someone with a general physics and mathematics background, e.g., comparable to a Scientific American or more advanced.

This course is a writing intensive class. Students will be expected to produce writing that
- Demonstrates their understanding of course content,
- Is appropriate for the audience and purpose of a particular writing task,
- Demonstrates the degree of mastery of disciplinary writing conventions appropriate to the course (including documentation conventions), and
- Shows competency in standard edited American English.

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attendance</td>
<td>Students are expected to attend each and every class session. As the class will consist of multiple research presentations, tours, and group work, it is essential that students attend.</td>
</tr>
<tr>
<td>Abstract/Summary</td>
<td>Students will develop an abstract of their research proposal including the problem posed and the proposed methodology.</td>
</tr>
<tr>
<td>Written Proposal</td>
<td>Students must complete a minimum 5 page proposal that includes an abstract, background, methodology and budget. Students will submit drafts of the final report and will receive written feedback from the advisor so that the students may submit a revised final draft.</td>
</tr>
<tr>
<td>Oral Proposal</td>
<td>All students will give a presentation of the written proposal to the class and a panel of program faculty near the end of the semester.</td>
</tr>
</tbody>
</table>

This is a course guideline syllabus. Course materials, method of instruction, evaluation and policy, grading policy, assignments, and other course matters can differ by specific course sections and individual professors. Additional information can be obtained by contacting the appropriate college and department.
I. College/School: COSM  
Department: MATH-STAT & PHYSICS

II. Course Information
- Course Title: IASM Graduate Seminar
- Credit Hours: 2
- Course Abbreviation and Number: 8100
- Course Cross Listing(s) Abbreviation and Number:
  Check (“x”) all applicable:
  - Writing Intensive
  - Service Learning
  - Laboratory
  - Laboratory Grade Separate
  - Ohio TAG (Transfer Assurance Guideline) Course
  - Ohio Transfer Module Course

III. Course Registration
- Prerequisites:
- Corequisites:
- Restrictions: Admission into the IASM Ph.D. program
- Other: permission of the department

IV. Course Objectives

Convention of student body and faculty from the IASM program to learn, discuss, and critique current and evolving research in fields relevant to the IASM program mission as presented by an active and reputable scientific investigator. Centered around guest lecturer and student presentations.

VI. Suggested Course Materials (required and recommended)
- None

VII. Suggested Method of Instruction - Lecture/Seminar

VIII. Suggested Evaluation and Policy

- Course requirements:
  - Attendance – 50% of final grade
  - One Page Seminar Reports – 25% of final grade (submitted for every presentation)
  - Oral Research Presentation – 25% of final grade (outline = 5%, presentation = 20%)

- Course Grading
  - A: 90-100%, B: 75-89.9%, C: 60-74.9%, D: 50-59.9%, F: < 50%

This is a course guideline syllabus. Course materials, method of instruction, evaluation and policy, grading policy, assignments, and other course matters can differ by specific course sections and individual professors. Additional information can be obtained by contacting the appropriate college and department.
IASM 8200 Semester Internship

I. College/School   COSM
Department       MATH-STAT & PHYSICS

II. Course Information
   Course Title: IASM Semester Internship
   Credit Hours: (variable) 3-6
   Course Abbreviation and Number: 8200
   Course Cross Listing(s) Abbreviation and Number:
   Check (“x”) all applicable:
   Writing Intensive Service Learning Laboratory Laboratory Grade Separate____
   Ohio TAG (Transfer Assurance Guideline) Course Ohio Transfer Module Course____

III. Course Registration
   Prerequisites: IASM 8000, 8010 Introduction to Research I, II

IV. Course Objectives
   Many of the research fields encompassed by the IASM Ph.D. program are ones that are utilized and applied outside of academia in commercial and government research, product development and business. This internship will take place at an off-campus public or private entity engaged in work relevant to IASM Program oriented research topics in order to gain practical experience with aspects of interdisciplinary applied science and mathematics. Participating students will have an on-site advisor as well as a faculty advisor. The internship grade will be assigned based on attendance, a student journal, a final report, and the evaluation report of the on-site advisor.

VI. Suggested Course Materials (required and recommended) - None

VII. Suggested Method of Instruction - Internship

VIII. Suggested Evaluation and Policy

   Course requirements:
   Attendance – 25% of final grade
   Weekly Journal – 25% of final grade
   Final Written Report – 25% of final grade (outline = 5%, presentation = 20%)
   Evaluation by On-Site Advisor – 25% of final grade

   Course Grading

   A: 90-100%, B: 75-89.9%, C: 60-74.9%, D: 50-59.9%, F: < 50%

This is a course guideline syllabus. Course materials, method of instruction, evaluation and policy, grading policy, assignments, and other course matters can differ by specific course sections and individual professors. Additional information can be obtained by contacting the appropriate college and department.
Appendix D: IASM Program of Study Form

Ph.D. in Interdisciplinary Applied Sciences and Mathematics Program of Study

Name: ____________________________ Date: ______________ UID: ______________________

Focus Area: ________________________ Dissertation Advisor: _______________________

Date Entered Ph.D. Program (Term/Year): __________

Entered Program after: B.S. ________

M.S. ________

Date M.S. Degree Awarded (Month/Year): __________

Name of Institution: ____________________________________________

Important Notes:

• Information must be typed.
• Please save your completed form electronically for future reference and revisions.
• For questions concerning formatting and compliance with Program rules and regulations, please see the program coordinator.
• For assistance in selecting courses, or to determine the correct placement of courses within your program of study, please consult your advisor and/or your focus area chair.

<table>
<thead>
<tr>
<th>Category</th>
<th>Course Number</th>
<th>Course Title</th>
<th>Credit Hours (CR)</th>
<th>When Taken (Term/Yr)</th>
<th>Grade</th>
<th>MS (max 30 CR) (✓)</th>
<th>Other or transfer (✓)</th>
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<tbody>
<tr>
<td>Core Courses (6 CR)</td>
<td>MTH 6060</td>
<td>Mathematical Modeling</td>
<td>3</td>
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<tr>
<td></td>
<td>MTH 6150</td>
<td>Scientific Computation</td>
<td>3</td>
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<td>Focus Area Courses (≥6 courses) (2 Focus Areas represented)</td>
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<td></td>
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<tr>
<td>Category</td>
<td>Course Number</td>
<td>Course Title</td>
<td>Credit Hours (CR)</td>
<td>When Taken (Term/Yr)</td>
<td>Grade</td>
<td>MS (max 30 CR) (✓)</td>
<td>Other or transfer (✓)</td>
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<tr>
<td>IASM Courses (min 10 CR)</td>
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<td>IASM Introduction to Research I</td>
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<td>8010</td>
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<tr>
<td></td>
<td>8100</td>
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<tr>
<td></td>
<td>8100</td>
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<td>Elective</td>
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<tr>
<td>Courses (min 4) (6000-level or above)</td>
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<td>IASM Semester Internship (optional elective substitute)</td>
<td>Subtotal</td>
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<td>Independent Research (4-6 CR)</td>
<td>8300</td>
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<tr>
<td>Research (min 40 CR)</td>
<td>8400</td>
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<td>Total CR</td>
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<td>Minimum 90</td>
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**Approvals:**  

*Must be obtained in order listed*  

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<tr>
<th>Approval</th>
<th>Signatures</th>
<th>Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Student Signature:</td>
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<tr>
<td><strong>Format Approval</strong></td>
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<tr>
<td>2. Program Coordinator:</td>
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<tr>
<td><strong>Coursework Approval</strong></td>
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<td>3. Dissertation Advisor:</td>
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<td><strong>Coursework Approval</strong></td>
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<td>4. Focus Area Chair:</td>
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<td><strong>Final Approval</strong></td>
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<td>5. Program Director:</td>
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## Appendix E: IASM Program Timeline

<table>
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<tr>
<th>Program Milestone Activities</th>
<th>Time Period</th>
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<tbody>
<tr>
<td>- Selection of Focus Area</td>
<td>Year 1 – Semester 1</td>
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<tr>
<td>- Take IASM Intro. to Research I</td>
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<tr>
<td>- Advanced students begin participating in research projects.</td>
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<tr>
<td>- Take IASM Intro. to Research II</td>
<td>Year 1 – Semester 2</td>
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<tr>
<td>- Submit preliminary program of study</td>
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<tr>
<td>- Complete IASM Core Courses</td>
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<tr>
<td>- Take IASM Graduate Seminar</td>
<td>Year 2 – Semester 1 &amp; 2</td>
</tr>
<tr>
<td>- Select dissertation advisor &amp; engage in research</td>
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<tr>
<td>- Take Qualifying Exam</td>
<td>Year 2 – Conclusion of 2nd semester</td>
</tr>
<tr>
<td>- Complete semester-long internship (optional)</td>
<td>Year 3</td>
</tr>
<tr>
<td>- Submit revised program of study</td>
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<tr>
<td>- Identify dissertation committee</td>
<td>Year 4 – Semester 1</td>
</tr>
<tr>
<td>- Take Candidacy Exam (research proposal)</td>
<td>After completion of coursework but no less than 180 days prior to dissertation defense</td>
</tr>
<tr>
<td>- Conduct dissertation seminar</td>
<td>Prior to dissertation defense</td>
</tr>
<tr>
<td>- Submit journal article or conference abstract</td>
<td>Prior to dissertation defense</td>
</tr>
<tr>
<td>- Apply for graduation</td>
<td>Within the 1st 3 weeks of semester of intended graduation</td>
</tr>
<tr>
<td></td>
<td>(check with Graduate School for deadline)</td>
</tr>
<tr>
<td>- Distribute copies of dissertation to dissertation committee and focus area chair</td>
<td>Two weeks before dissertation defense</td>
</tr>
<tr>
<td>- Dissertation defense</td>
<td>Account for sufficient time to complete and submit dissertation corrections.</td>
</tr>
<tr>
<td>- Upload dissertation to OhioLink</td>
<td>Permission of dissertation advisor</td>
</tr>
<tr>
<td>- Graduate and receive your doctoral hood</td>
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</tbody>
</table>
Appendix F: Selected IASM Course Descriptions

Math 6060 Mathematical Modeling – 3 hours
An introduction to mathematics as it is used in the real world. Graphical methods, curve-fitting, dimensional analysis, scaling, stability, growth, vibrations, circuits, probability, optimality, approximation, Monte Carlo simulation. Students will be encouraged to make creative use of mathematical and problem-solving skills, and asked to develop an original model.

MTH 6070 Optimization Techniques – 3 hours
Algorithms for optimizing real functions of several variables subject to equality and inequality constraints. Convexity properties of functions and sets, linear programming, simplex and interior point methods, integer programming, branch and bound algorithm, transportation problem, necessary and sufficient conditions for nonlinear function optimization, Newton and quasi-Newton methods, Lagrange multiplier conditions, Kuhn-Tucker conditions, dynamic programming.

MTH 6140 Mathematical Software – 3 hours

MTH 6150 Scientific Computing – 3 hours
Modern computational techniques for simulating scientific phenomena.

MTH 6240 Coding Theory – 3 hours
An introduction to the essentials of error-correcting codes, including methods for efficient and accurate transfer of information. Perfect and related codes, linear and cyclic codes, BCH codes, Reed-Muller codes, Reed-Solomon codes, Self-dual codes, weight enumerators and bounds.

MTH 6260 Matrix Computations – 3 hours
Numerical linear algebra survey using high-level computing tools. Topics include linear equations, matrix factorizations, eigenvalue problems, least squares, applications of singular value decompositions, and iterative methods for large sparse matrices. Conditioning of problems and accuracy and stability of algorithms are emphasized.

MTH 6570 Combinatorics and Graph Theory – 4 hours
Topics include: permutations, combinatorics, generating functions, recurrence relations, and Polya's theory of counting; methods, results, and algorithms of graph theory, with emphasis on graphs as mathematical models applicable to organizational and industrial situations.

MTH 6810 Applied Mathematics I – 3 hours
**MTH 6820 Applied Mathematics II – 3 hours**

**MTH 7160 Numerical Analysis I – 4 hours**
Solutions of systems of linear and nonlinear equations, numerical solution of matrix eigenvalue problems, interpolation and numerical integration, numerical solution of initial and boundary value problems for differential equations.

**MTH 7170 Numerical Analysis II – 4 hours**
Finite difference and finite element methods for partial differential equations, including elliptic, parabolic and hyperbolic.

MTH 7310 Real Analysis I – 4 hours

MTH 7320 Real Analysis II – 4 hours

MTH 7770 Applied Analysis – 4 hours
Fixed point theorems and applications, Banach and Hilbert spaces and applications, compact operators, eigenvalues, eigenfunction expansions, Sturm-Liouville problems, inverse operators, variational methods, and basic approximate methods in analysis.

**PHY 6320 Lasers – 3 hours**
Introduction to the physics of lasers including emission and absorption processes in lasing, the factors controlling laser gain, the properties of optical resonators, and a survey of salient features for principal types of lasers.

**PHY 6730 Mathematical Physics – 3 hours**
Survey of mathematical physics including vector analysis, tensor analysis, calculus of several variables, ordinary and partial differential equations, integral equations, theory of distributions. Ability to apply these to mechanics, electromagnetism, and thermodynamics, and quantum mechanics.

**PHY 6400 Nanoscience and Nanotechnology – 3 hours**
Introduction to nanoengineering, nanoscience and nanotechnology. Topics include introduction to quantum mechanics, fabrication, characterization, materials, electronic properties, optical properties, magnetic properties, devices, MEMS, NEMS.
**PHY 6630 Introduction to Solid State Physics – 3 hours**
Selected properties of solids and their quantitative explanation in terms of simple physical models. Applications of quantum mechanics to solids.

**PHY 6810 Electromagnetic Theory I -- 4 hours**
Electromagnetic field theory emphasizing static and time dependent fields, field sources, and boundary value problems using advanced mathematical techniques.

**PHY 6820 Electromagnetic Theory II - 4 hours**
Understanding of formal Electromagnetic Theory including application of multipole treatments in Electro- and Magneto-statics, applications of relativity, and application of Maxwell’s equations to particular physical systems.

**PHY 6830 - Statistical Mechanics – 3 hours**
Introduction to microscopic and macroscopic physical systems developed from concepts of statistical physics. Application to classical and quantum systems will be presented as well as theories of phase transitions, critical phenomena and fluctuations.

**PHY 7100 Quantum Mechanics I – 3 hours**
Principles of non-relativistic quantum mechanics, Schrödinger's equation and matrix mechanics. Facility with applications to atomic, molecular, nuclear, solid state, spin, and biological systems.

**PHY 7110 Quantum Mechanics II – 3 hours**
Continuation of PHY7100. Principles of non-relativistic quantum mechanics, Schrödinger's equation and matrix mechanics. Facility with applications to atomic, molecular, nuclear, solid state, spin, and biological systems.

**PHY 7530 Topics in Ultrafast Optics – 3 hours**

**PHY 7540 – Topics in Geophysics – 3 hours**
The physics of the earth's crust, and atmosphere. Applications of physical principles to such processes as fluid flow in the crust, friction with in the crust, measurements of crust structure, fluid flow in the atmosphere, interaction of the atmosphere with radiation, and weather.

**PHY 7550 Topics in Terahertz Physics – 3 hours**
The interaction of high frequency electromagnetic radiation with materials with emphasis on the Terahertz region of the spectrum. Ability to apply these interactions to the function and design of high frequency electronic devices and/or to molecular systems.

**ES 7120 Environmental Biology: Genes, Organisms, and Ecosystems – 3 hours**
Graduate level introduction to environmental biology at multiple levels of biological organization including molecular biology, organismal physiology and evolutionary biology, and community and ecosystem ecology.
ES 7180 Chemical Processes in the Environment – 3 hours
Skills are developed to predict behavior and movement of chemical contaminants in atmospheric, aquatic and soil systems. Physical and chemical properties of contaminants and environmental interactions are evaluated to determine their ultimate fate.

ES 7160 Complexity in Environmental Systems – 4 hours
This interdisciplinary course explores mathematical methods for quantitative analysis and modeling of complex nonlinear environmental systems. The course introduces the concepts and tools for analyzing and modeling: scaling in space and time, feedback, and self-organization in environmental systems including: ecology, hydrology, global climate change, and geodynamical systems. Two hours lecture and two hours lab are combined.

EES 6120 Earth Materials – 4 hours
This course provides an understanding of the minerals and rocks that make up the solid earth, their significance and uses. Based upon the 'rock cycle' the materials studied include the rock-forming minerals as well as their weathered products. The laboratory focuses upon the identification and classification of minerals and rocks in hand specimen.

EES 6160 Stratigraphy & Sedimentology – 4 hours
Clastic and carbonate sedimentary rocks, their mineralogy, texture, provenance, and classification. Principles, rules, and geologic and geophysical correlation techniques. Fluid flow sediment transport and deposition, sedimentary structures, and depositional environments. Three hours lecture, two hours lab.

EES 6210 Structural Geology and Tectonics – 4 hours
Study of the three-dimensional distribution of rock units. Deformational structures such as folds, faults, joints, cleavage, foliation, and lineation and their superposition are used to unravel the history of deformation, and ultimately to understand the stress fields that produced the observed strain and structures. Tectonics is the structural evolution of regional patterns of deformation at the scale of mountain ranges. Lecture/lab combined; 4 credit hours.

EES 6220 Introduction to Geophysics – 4 hours
In Introduction to Geophysics students learn the methods and concepts of practical exploration geophysics. We deal with the five main methods of exploration: seismic refraction, seismic reflection, gravity methods, electrical methods, and magnetic methods. The lectures are put into practice during Saturday field work in the vicinity of the campus to characterize the near surface.

EES 6240 Oceanography – 3 hours
Introduction to the interrelated geology, physics, chemistry, and biology of the ocean.

EES 6250 Climate Change – 3 hours
This lecture course deals with the causes and variations of temperature and precipitation patterns over tens to millions of years, the mechanisms that drive them: air pollution, orbital and solar variation, plate tectonics, etc. It includes the nature of evidence for previous climatic conditions and the bases for predictions of future climate change.

EES 6290 Remote Sensing of Earth – 3 hours
In Remote Sensing and Digital Image Processing students learn the methods and concepts of remote sensing from an Earth Sciences perspective. Students learn to interpret various types of images including stereo air photos, airborne multi-spectral digital images and satellite images. Hands-on digital image processing is conducted using industry standard software.
BIO 6460 Advanced Cell Biology – 3 hours
Students will gain a thorough understanding about eukaryotic cell structures and functions including the organization of the cell nucleus, DNA replication, the multiple steps of gene expression, membrane composition and dynamics, and the importance of the cytoskeleton for cell motility, cell division and cell adhesion.

BIO 6470 Population & Community Ecology – 3 hours
Derivation and use of deterministic and stochastic population models, methods of analyzing community structure, composition, and dynamics

BIO 6600 Population Genetics – 4 hours
Examination of the causes of genetic differences within and among species and how molecular biology techniques can be used to identify these differences. Emphasized human genetics, anthropology, ecology and conservation implications.

BMB 7500 Molecular Biochemistry I – 3 hours
Also listed as BMS 7500. Survey course emphasizing experimental and problem-solving approaches to understanding amino acids, protein structure, enzymes, nucleic acid structure and DNA replication

BMB 7520 Molecular Biochemistry II – 3 hours
Survey course emphasizing an experimental and problem-solving approach to metabolism, nucleic-acid function, protein synthesis, membranes and hormones.

STT 6260 Survival Analysis – 3 hours
Censoring and truncation, survival and hazard functions, estimation and hypothesis tests, Cox proportional hazards model; diagnostics of the Cox model; state-of-the-art software for survival analysis models.

STT 6300 Biostatistics – 3 hours
Statistical methods suitable for analysis of data arising in biological and related studies. Estimation and hypothesis testing are reviewed. Methods include one and two sample tests, simple and multiple regression, and analysis of variance.

STT 6640 Computational Statistics – 3 hours

STT 7020 Applied Stochastic Processes – 3 hours
Stationary processes, Markov chains, Poisson processes, pure birth process, queuing processes, inventory problems, traffic flow problems, introduction to financial processes.

STT 7140 Environmental Statistics – 4 hours
Statistical techniques for the modeling and analysis of environmental data including advanced regression techniques, generalized linear models, and random effects. Also modeling of spatial and time-series environmental data, including spatio-temporal analysis, using appropriate software. Applications and case studies.
STT 7440 Applied Multivariate Statistics – 3 hours
Matrix theory, multivariate distributions, likelihood ratio tests, MANOVA, principal component and factor analysis, canonical correlation analysis, finite mixture models and the EM algorithm, and classification techniques.

STT 7670 Applied Regression Analysis – 3 hours
Stationary processes, Markov chains, Poisson processes, pure birth process, queuing processes, inventory problems, traffic flow problems, introduction to financial processes.

CHM 6170 - Applied Chemical Spectroscopy – 2 hours
Practical applications of various spectrophotometric techniques (mass spectroscopy, infrared spectroscopy, ultraviolet spectroscopy, and nuclear magnetic resonance) are integrated for the explanation of the structure of organic molecules. A problem-solving approach is used.

CHM 6650 Physical Polymer Chemistry – 2 hours
Practical applications of various spectrophotometric techniques (mass spectroscopy, infrared spectroscopy, ultraviolet spectroscopy, and nuclear magnetic resonance) are integrated for the explanation of the structure of organic molecules. A problem-solving approach is used.

CHM 6680 Experimental Nanomaterials and Nanoscience -- 3 hours
This course will provide a series of laboratory experiments similar to the state-of-the-art R&D in nanotechnology and nanoscience. The experiments include 1) fabrication of nanomaterials such as metal nanoparticles and graphene nanoplatelets; 2) characterization of physical and chemical properties by using techniques such as Raman spectroscopy, atomic force microscopy, terahertz spectroscopy, electrochemical analyses etc; and 3) computational modeling of nanoscale physical phenomena.

CHM 7500 Introduction to Quantum Chemistry – 3 hours
Introduction to the ideas and mathematical techniques of quantum theory, including applications to some simple chemical systems.

PSY 7050 Cognition -- 3 hours
Phenomena, principles, and problems of human cognition and learning.

PSY 7060 Perception -- 4 hours
Study of the active processes by which organisms gather, interpret, and respond to environmental stimuli.

PSY 8110 Applications of Visual Science – 3 hours
Study of the active processes by which organisms gather, interpret, and respond to environmental stimuli.

PSY 8130 Fundamentals of Motion Detection -- 3 hours
A detailed introduction to visual motion perception, covering historical, psychophysical, neural, computational, and applied perspectives.

PSY 8140 Psychoacoustics -- 3 hours
A detailed introduction to visual motion perception, covering historical, psychophysical, neural, computational, and applied perspectives.
NOTE:

The following Appendix items are attached to this proposal as additional documents in the following order:

Appendix G: IASM Program Faculty Vitae

Appendix H: IASM External Advisory Board Letters of Support

Appendix I: Hanover Research Feasibility Study

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1 Facilitating Interdisciplinary Research, report of Committee on Facilitating Interdisciplinary Research, Committee on Science, Engineering, and Public Policy, National Academies, Washington, 2004
2 The Ohio State University Department of Physics, “Progress to Ph.D.,” https://physics.osu.edu/progress-phd
3 The Ohio State University Department of Mathematics, “Doctor of Philosophy (PhD),” https://math.osu.edu/grad/current/phd
5 The University of Wisconsin Department of Mathematics, “Ph.D. Requirements,” http://www.math.wisc.edu/graduate/phd-requirements
8 Wright State University Ph.D. in Engineering Program, “Degree Requirements,” http://cecs.wright.edu/programs/doctoral/engineering/students/current/requirements
K.T. Arasu

Personal Data:
Address: Department of Mathematics and Statistics, Wright State University, Dayton, OH 45435
Phone: 937 775-3828; Fax: 937 775-2081; E-mail: k.arasu@wright.edu

Education:
1976 B. Sc (Hons) Panjab University, India; Mathematics
1977 M. Sc (Hons) Panjab University, India; Mathematics
1983 Ph.D. Ohio State University; Mathematics

Professional Career:
Assistant Professor, Wright State University, 1983 – 1989
Associate Professor, Wright State University, 1989 - 1994
Professor, Wright State University, 1994 -

Research Interests:

Publications: (10 recent)
Synergistic activities:

Developed a course on Cryptography and data security, which is a very popular course here. With the NSF support, gave research experience for more than 70 undergraduate students (REU supplement), four of these students went on to Ph.D., these have publishable results written up, about 30 of these students were women, one of these is a black, handicapped woman. With the RET supplement from NSF, I gave research experience to high school teachers - exposed them to finite field arithmetic using polynomial approach and taught them how encryption/decryption methods work, developed a work bench to handle this task using C-language. Editor of the Journal Designs, Codes and Cryptography. Guest editor for a couple of journals and special issues. Gave invited and plenary talks at 115 international conferences. Organizer and Co-organizer of 10 international conferences. Research grants from NSF, AFOSR and NSA for the past 25 years, totaling over 1.5 million dollars – all for basic research, no equipment money.

Supervision of Graduate students:

1. Supervised a Ph. D. thesis (The Ohio State University).
2. Supervised six masters theses.
3. Supervised over 70 research assistants.
5. Invited external examiner of thesis for University of Wales, UK, Singapore and University of Hong Kong.

Honors:

1. Awarded medal by Punjab University for first rank in B. Sc. (Hons).
2. Awarded medal by Panjab University for first rank in M. Sc (Hons).
3. Adjudged best participant at the special coaching for gifted students, Presidency college, Madras, India, October 1972.
4. Adjudged as one of the best participants at the summer institute at Bangalore University conducted by Professor Arnold E. Ross of the Ohio State University, Sponsored by University Grants Commission and National Science Foundation, June 1973.
5. First Prize: Math Talent exam conducted by the All India Teacher’s Association, 1973.
6. Invited Panelist by NSF to rank grant proposals. (Multiple times)
7. Winner of the teaching excellence award at Wright State University, College of Science and Math, 1987-88.
8. Winner of the Presidential award for excellence in research at Wright State University, 2001.
9. Winner of the Trustee’s award for Faculty Excellence at Wright State University, 2005.
Volker Bahn

Personal Data:
Address: Department of Biological Sciences, Wright State University, Dayton, OH, 45435
Telephone: (937) 775-4152; FAX (937) 775-3320; E-mail: volker.bahn@wright.edu

Education:
2005-2008 Postdoctoral Scholar McGill University, Montréal, Québec, Canada
2002-2005 Ph.D. University of Maine, Orono, Maine, USA
1991-1998 M.S. Philipps-Universität, Marburg, Germany

Professional Activities & Awards:
PeerJ, Editorial Board (2013-present) Reviewer for 24+ journals and granting agencies
One paper is editorial pick in March 2013 edition of Oikos, a second was featured in a commentary in
the Journal of Biogeography by David Currie and has been evaluated as “must read” by George
Malanson for the Faculty of 1000 Biology.

Professional Career:
2013-present Associate Professor, Wright State University, Dayton, OH
2008-13 Assistant Professor, Wright State University, Dayton, OH
2000-01 Research Scientist, University of Victoria, British Columbia, Canada
2000 Research Associate, Auburn University, Auburn, Alabama
1999-2000 Project Leader, University of Victoria, Victoria, BC, Canada, Field Biologist and
Nanaimo, BC, Canada (summers)

Scholarly Activities:
Publications: 19
Presentations and Invited Lectures: 41
Graduate Dissertations and Theses Directed: 2
Funding: $28,359 Eppley Foundation, $124,331 (in past 5 yrs.)

Publications: (10 recent)


Top downloaded paper in Ecological Modelling in 2011


This paper is featured in a commentary in the Journal of Biogeography by David Currie, the editor of Global Ecology and Biogeography and has been evaluated as “must read” by George Malanson for the Faculty of 1000 Biology.
Christopher C. Barton

Personal Data:
Department of Earth and Environmental Sciences, Wright State University, Dayton, OH, 45435
Telephone: (937) 775-3444; FAX (937) 775-3444; E-mail: chris.barton@wright.edu

Education:
1983 Ph.D. Yale University; Geology and Geophysics
1977 M.Phil. Yale University; Geology and Geophysics
1976 M.S. Yale University; Geology and Geophysics
1974 B.A., Geology, Alfred University

Professional Activities & Awards:
International Journal of Fractals, Editorial Board (1992-present)

Founding member Nonlinear Geophysics Focus Group, American Geophysical Union
Chair, Nonlinear Geophysics Focus Group, American Geophysical Union (2000-2002)
Executive Committee, Nonlinear Geophysics Focus Group, American Geophysical Union (2002-present)
Trustee of Hubbard Brook Research Foundation, Hanover, NH (2002-Present)
Norwegian Academy of Science and Letters, invited visiting scientist (May, 1993)
Oxford University Centre for Industrial and Applied Mathematics, invited scientist (May 1994)

Professional Career:
2004-present Professor of Nonlinear Dynamics and Complex Systems, Wright State University
1982-83 Postdoctoral Fellow, Department of Material Science and Mining Engineering, UC Berkeley, Berkeley, CA

Scholarly Activities:
Publications: 64 journal articles and reports, 2 books
Presentations and Invited Lectures: 112
Graduate Dissertations and Theses Directed: 3
Funding: $175,000 from WSU over the past 10 years

Publications: (10 recent)


7. Murnane, R.J.; Barton, Chris; Collins, Eric; Donnelly, Jeffrey; Elsner, James; Emanuel, Kerry; Ginis, Isaac; Howard, Susan; Landsea, Chris; Liu, Kam-bui; Malmquist, David; McKay, Megan; Micheals, Anthony; Nelson, Norm; O’Brien, James; Scott, David; Web III, Thompson, 2000, Model estimates hurricane wind speed probabilities: Eos, Transactions of the American Geophysical Union, v. 81, no. 38, p.433 and 438.


Elliott Brown

Personal Data:
Address: Department of Physics, Wright State University, Dayton, OH, 45435
Telephone: (937) 775-4903; E-mail: elliott.brown@wright.edu

Primary Education:
1985 Ph.D. California Institute of Technology (Caltech); Applied Physics
Thesis research supervised by Professor Thomas G. Phillips
1981 M.S. Caltech; in Applied Physics
1979 B.S. University of California, Los Angeles (UCLA); Physics

Other Education:
1978 Infrared Detectors and Technology, Univ. of California, Santa Barbara
1989 Silicon Microelectronic Fabrication, MIT Lowell School
1997 Voice and Data Telecommunications, Two-Rivers Technologies

Professional Experience:
2010- Professor of Physics and Electrical and Computer Engineering, Wright State University
2004-2010 Professor of Electrical and Computer Engineering, Univ of California, Santa Barbara
1998-2004 Professor of Electrical Engineering, Univ. of California, Los Angeles
1995-1998 Program Manager, DARPA Electronics Technology Office
1994-1995 Assistant Manager, MIT Lincoln Laboratory, High-Speed Electronics Group
1985-1994 Project Leader and Research Staff Member, MIT Lincoln Laboratory
1980-1985 Graduate Research Assistant, Caltech
1977-1981 Bachelor’s & Master's Fellow, Hughes Space and Communications Group

Conference and Journal Committees:
2012 Co-Chairman IEEE Sensors 2013 Conference
2009 IEEE Sensors Journal Associate Editor
2007 IEEE Transactions Editorial Board
1994 Technical Program Committee: IEEE Device Research Conference (DRC)
1994 Technical Program Committee: OSA Ultrafast Electronics and Optoelectronics

Other Academic Affiliations:
1994-1996 Adjunct Professor, Northeastern University.
1994-1995 Research Affiliate, MIT Research Laboratory of Electronics.
Honors and Awards:

2013  IEEE Harrel V. Noble Electron Devices Award, Dayton Section
2010  Ohio Research Scholars Chair in THz Sensors Physics
2007  Fellow, American Physical Society
2000  Fellow, Institute of Electrical and Electronics Engineers.
1998  Award for Outstanding Achievement, U.S. Office of the Secretary of Defense
1983-1985 Achievement Rewards for College Scientists (ARCS) Fellowship.
1979-  Lifetime enrollment, Phi Beta Kappa National Honor Society.
1979  Graduated Summa Cum Laude with Major in Physics, UCLA.
1979  Kinsey Award for Outstanding Graduating Physics Student, UCLA.

Personal:
Date of Birth: 4 October 1955; Citizenship: USA

Written and Oral Technical Communications:
Over 270 technical papers, book chapters, and review articles in the open literature.
Over 110 invited talks at scientific conferences; 13 U.S. patents.
Yuqing Chen

Personal Data:
Address: Department of Mathematics and Statistics, Wright State University, Dayton, OH, 45435
Telephone: (937) 775-3835; FAX: (937) 775-2081; E-mail: yuqing.chen@wright.edu

Education:
1997  Ph.D  Ohio State University;  Mathematics
1985  B.S  Fudan University, Shanghai, China;  Mathematics

Professional Career:
2009-present Associate Professor, Dept. of Mathematics and Statistics, Wright State University
2004-2009  Assistant Professor, Dept. of Mathematics and Statistics, Wright State University
1998-2004  Post-doctoral fellow and Lecturer, Department of Mathematics, RMIT

Publications:  (10 recent)

1. Y. Q. Chen and T. Feng, “Paley type sets from cyclotomic classes and Arasu-Dillon-Player difference sets”, (to appear in Designs, Codes and Cryptography)
Personal Data:
Address: Department of Physics, Wright State University, Dayton, OH, 45435
Telephone: (937) 775-2148; FAX (937) 775-2222; E-mail: jason.deibel@wright.edu

Education:
2004 Ph.D University of Michigan, Ann Arbor; Applied Physics
1997 B.A Transylvania University; Physics and Mathematics,

Professional Activities & Awards:
Intl. Jnl. of Infrared, Millimeter, and Terahertz Waves, Editorial Board (2012-current)

Committee Chair, OSA Optical Sensors Meeting 2012 “Terahertz Sensors”

Organizing Committee, “Materials Research for Terahertz Technology Development Symposium,”
Spring 2009 Materials Research Society Meeting

Member, Local Planning Committee, Fall 2008 Meeting of the Ohio Section of the American Physical Society (hosted by Wright State University)


Grant reviewer: US Defense Threat and Reduction Agency, Canada Foundation for Innovation Leaders Opportunity Fund, National Science Foundation

Co-Recipient of Wright State University Learning Community 2013 award for Outstanding Collaboration between a faculty member and a peer instructor

Recognition for Faculty Contribution to the Writing Across the Curriculum Program at Wright State University (Nominated by students), April 2013

Recognition for Faculty Contribution to the University General Education Program at Wright State University (Nominated by students), April 2013

Professional Career:
2013-present Associate Professor, Dept. of Physics, Wright State University

2007-2013 Assistant Professor, Dept. of Physics, Wright State University
2004-2007  Postdoctoral Research Associate, Dept. Electrical and Computer Engineering, Rice University

2006- Visiting Fellow, Royal Society North America Incoming Short Visit Program, University of Leeds

**Scholarly Activities:**

Publications & Refereed Conference Proceedings: 38

Presentations and Invited Lectures: 27

Graduate Dissertations and Theses Directed: 6

Funding: $4,800,000 (National Science Foundation, Ohio Board of Regents, Air Force Research Laboratory, Office of Naval Research, Private Corporations)

**Publications:** (10 recent)


Joanne Dombrowski

Personal Data:
Address: Department of Mathematics and Statistics, Wright State University 45435
Telephone: (937) 775-3218; E-mail: joanne.dombrowski@wright.edu

Education:
1973 Ph.D. Mathematics, Purdue University
1970 M.S. Mathematics, Purdue University
1968 B.S. Mathematics, Marygrove College

Professional Career:
1990-present Professor, Department of Mathematics and Statistics, Wright State University
1978-1990 Associate Professor, Department of Mathematics and Statistics, Wright State University
1973-1978 Assistant Professor, Department of Mathematics and Statistics, Wright State University
1973 Instructor, Purdue University (Summer)

Scholarly Activities:
22 Publications
26 Presentations and Invited Lectures

Publications (10 recent):
Anthony B. Evans

Personal Data:
Address: Department of Mathematics and Statistics, Wright State University, Dayton, OH, 45435
Telephone: (937) 775-2486; E-mail: anthony.evans@wright.edu

Education:
1981 Ph.D, Mathematics, Washington State University
1972 M.S., Mathematics, Reading University
1970 B.S., Mathematics, Imperial College of Science and Technology

Professional Activities & Awards: Member American Mathematical Society
Foundation Fellow of the Institute for Combinatorics and its Applications

Referee for several journals
Reviewer for Math. Reviews

Professional Career:
1996-present Professor, Dept. of Mathematics and Statistics, Wright State University
1987-1996 Associate Professor, Dept. of Mathematics and Statistics, Wright State University
1981-1987 Assistant Professor, Dept. of Mathematics and Statistics, Wright State University
1973-1975 Instructor, University of Petroleum and Minerals

Scholarly Activities:
Publications: 47
Books: 1
Presentations and Invited Lectures: 70
Graduate Dissertations and Theses Directed: 1
External Associate Supervisor for PhD student at Monash University, Melbourne, Australia

Publications: (10 recent)


Weifu Fang

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Address: Dept of Math and Stat, Wright State University, Dayton, OH, 45435
Telephone: (937)775-2785; FAX (937)775-2081; E-mail: weifu.fang@wright.edu

Education:
1990 Ph.D, Mathematics, Claremont Graduate University
1985 M.S., Mathematics, South China University of Technology
1982 B.S., Mathematics, South China University of Technology

Professional Career:
2008-present Professor and Chair, Dept. of Mathematics and Statistics, Wright State University
2002-2008 Professor, Dept of Mathematics, West Virginia University
1997-2002 Associate Professor, Dept of Mathematics, West Virginia University
1992-1997 Assistant, Dept of Mathematics, West Virginia University
1990-1992 Visiting Assistant Professor, Dept of Mathematics, University of Southern California

Publications: (10 recent)

Gary C. Farlow

Personal Data:
Address: Department of Physics, Wright State University, Dayton, OH, 45435
Telephone: (937) 775-3340; FAX (937) 873-3340; E-mail:gary.farlow@wright.edu

Education:
1977  B. S.  Physics and Mathematics  Guilford College
1982  Ph.D.  Solid State Physics  UNC-Chapel Hill

Professional Activity:
Participant in drafting of COSM bylaws 1999-2001
Served as a consultant to and participant in the Ohio Department of Health Advisory Committee which reviewed comments on the state regulations governing radiation producing devices (Ohio Revised Code sections 3701:1-66-02 and 3701:1-66-17)

Affiliate: Surface Modification and Characterization Facility, Oak Ridge National Laboratory 1987-2003,
Center for Semiconductor Research 2001- present

PROFESSIONAL HISTORY
1/1996 - 8/96  Professional leave  Oak Ridge National Laboratory
9/1989 – Present  Assoc. Professor  Wright State University
3/1988 - present  Graduate Faculty  Wright State University
1983 - 1984  ORAU Postdoctoral Fellow  Oak Ridge National Laboratory
1979 - 1982  Research Assistant  UNC-Chapel Hill
1977 - 1978  Teaching Assistant  UNC-Chapel Hill
1976  Teaching Assistant  Guilford College
Scholarly Publications: 57
Presentations and Invited Lectures: 9
Graduate Dissertations and Theses Directed: 9
Funding: $101,120 in donated equipment and contracts for electron irradiation.
Scholarship:

John M. Flach

Personal Data:
Address: Department of Psychology, Wright State University, Dayton, OH, 45435
Telephone: (937) 775-2319; FAX (937) 775-3347; E-mail: john.flach@wright.edu

Education:
Ph.D. Human Experimental Psychology 1984 The Ohio State University
M.A. Psychology 1978 University of Dayton
B.A. Psychology 1975 St. Joseph's College, Indiana

Professional Activities & Awards:
1992 Dean's Collaborative Teaching Award, College of Science and Mathematics, Wright State.
UES-AFOSR Summer Faculty Fellowship, Armstrong Aerospace Medical Research Laboratory, Wright Patterson Air Force Base. Summer 1985.
Arthur O. Beckman Research Award, University of Illinois, 1985.
SCEEE-AFOSR Summer Graduate Student Fellowship, Armstrong Aerospace Medical Research Laboratory, Wright Patterson Air Force Base. Summer 1984.
Alumni Research Award, Graduate School, The Ohio State University, 1982.
Toop's Research Award, Department of Psychology, The Ohio State University, 1982.

Professional Career:
1998 – Present Professor, Departments of Psychology and Biomedical Industrial and Human Factors Engineering, Wright State University
2004 – 2012 Chair, Department of Psychology, Wright State University
2004 (Jan – Mar) Visiting Professor, Departments of Aeronautical, Mechanical, and Industrial Design Engineering, TU Delft (Sabbatical from WSU)
2000 (May - June) Erskine Fellow. University of Canterbury, Christchurch, NZ.
1994 - 1998 Associate Professor, Department of Psychology Wright State University
1990 – 1996 Adjunct Research Scientist Air Force Research Laboratory, Wright Patterson AFB
1990 - 1994 Assistant Professor, Department of Psychology Wright State University
1984 - 1990 Assistant Professor, Department of Mechanical & Industrial Engineering, Department of Psychology, Institute of Aviation, University of Illinois at Urbana-Champaign

1983-1984 Coordinator for Introductory Psychology Program
The Ohio State University

1982-1984 Teaching Associate (Introductory Psychology)
The Ohio State University

1978-1982 Research Associate, Supervisor: Dr. R.J. Jagacinski
The Ohio State University

1976-1978 Graduate Teaching Associate, University of Dayton

Scholarly Activities:

Publications: 157 (including books, journal articles, book chapters, and published conference proceedings)

Presentations and Invited Lectures: 115

Graduate Dissertations and Theses Directed: 11 Dissertations, 27 Theses

Funding: (in past 5 yrs.)


Choose Ohio First Scholarships for Students with disabilities pursuing STEM careers, State Of Ohio, $2.5 M. (2008 - 2013)

National Center for Technology Innovation (NCTI) Technology in the Works Competition Award, (Co-PI with Andrew Junker, Brain Actuated Technologies) 2009, $42,226.

NSF:RDE RAD: Ohio STEM Abilities Alliance (2008-2013) $2.5 M.


NSF, IGERT: Learning with Disabilities (PI, with Golshani, Wheatly and others) (2005-2010) $3 M.
Publications: (10 recent)

Brent D. Foy

Personal Data:
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Telephone: (937) 775-2571; E-mail: brent.foy@wright.edu

Education:
1991 Ph.D, Medical Physics, Massachusetts Institute of Technology
1985 B.S., Physics, Massachusetts Institute of Technology

Professional Activities & Awards:
ISRN Biomathematics, Editorial Board (2012-2014)

Professional Career:
2000-present Associate Professor, Dept. of Physics, Wright State University
1994-2000 Assistant Professor, Dept. of Physics, Wright State University
1991-1994 Research Fellow in Surgery, Massachusetts General Hospital

Scholarly Activities:
Publications: 25
Presentations and Invited Lectures: 21
Graduate Dissertations and Theses Directed: 13
Funding: $975,000 between 1998 and 2008 ($0 in past 5 yrs.)

Publications: (12 recent)


Lynn Hartzler

Personal Data:
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Telephone: (937) 775-2163; FAX (937) 775-3320; E-mail: lynn.hartzler@wright.edu

Education:
2005    Ph.D, Biological Sciences, University of California, Irvine
1998    M.S., Biology, The University of Akron
1995    B.S., Biology, The University of Akron

Professional Activities & Awards:
President, past-president, Ohio Physiological Society (chapter of the American Physiological Society)
Faculty mentor for Wright State University’s STREAMS program (Short Term Research Experience: Access for Minority Students)
Reviewer for Physiological and Biochemical Zoology, Journal of Experimental Biology, Comparative Biochemistry and Physiology, American Journal of Physiology
Reviewer/panelist for National Science Foundation
Chair, University Honors Committee (Wright State University)

Professional Career:
2008-present    Assistant Professor: Biological Sciences, Wright State University
2005-2008    Postdoctoral Fellow: Neuroscience, Cell Biology, and Physiology, Wright State University’s Boonshoft School of Medicine
2004-2005    Lecturer: The University of Akron, Wayne College
1998-2004    Graduate Teaching Assistant: Ecology and Evolutionary Biology, University of California, Irvine
1996-1998    Graduate Teaching Assistant: Biology, The University of Akron

Scholarly Activities:

Publications: 18
Invited Presentations: 12
Graduate Dissertations and Theses Directed: 3
Funding: $390,525
Publications: (10 recent)


Joseph W. Houpt

Personal Data:
Address: Department of Psychology, Wright State University, Dayton, OH, 45435
Telephone: (937) 775-2391; FAX (937) 775-3347; E-mail: joseph.houpt@wright.edu

Education:
2012  Ph.D, Psychology and Cognitive Science, Indiana University
2007  M.S., Artificial Intelligence, University of Edinburgh
2005  B.S., Mathematics, University of Utah

Professional Activities & Awards:
SAGE Open, Editorial Board (2013-Present)
2014 Midwestern Cognitive Science Conference, Organizing Committee Co-Chair

Indiana University Cognitive Science Program Outstanding Dissertation Award (2013)

Professional Career:
2012-present Assistant Professor, Dept. of Psychology, Wright State University
2011-2012 Information Visualization Researcher, Ball Aerospace Technologies Corp.

Scholarly Activities:

Publications: 10

Presentations and Invited Lectures: 19

Publications:


Chao Cheng Huang

Personal Data:
Address: Department of Mathematics and Statistics, Wright State University, Dayton, OH, 45435
Telephone: (937) 775-2491; FAX (937) 775-2801; E-mail: chaocheng.huang@wright.edu

Education:
1995, Ph.D, Applied Mathematics, University of Minnesota

Professional Career:
1995-present Assistant, Associate, Full Professor, Dept. of Mathematics and Statistics, Wright State University

Scholarly Activities:
Publications: 35
Presentations and Invited Lectures: over 40

Research Interests:
Interdisciplinary: Particle Dynamics, System Reliability, Composites and Multiphase Materials, Modeling Underground Fluid, Modeling Derivative Pricing and Risks

Publications: (recent)
Qingbo Huang

Personal Data:
Address: Dept of Mathematics & Statistics, Wright State University, Dayton, OH 45435 Tel: (937)775-2147; Fax: (937)775-2081; E-mail: qingbo.huang@wright.edu

Education:
1998 Ph.D., Mathematics, Temple University 1986 M. S., Mathematics, Xiamen University 1983 B. S., Mathematics, Xiamen University

Professional Activities & Awards:
Outstanding Teaching Award, 2002-2003, College of Science & Mathematics, Wright State University Distinguished Teaching Award, 1998, College of Arts & Sciences, Temple University Reviewer for more than 10 mathematical journals, research grant proposals, and promotion and tenure case for another university

Professional Career:
2008-present Professor, Dept of Mathematics & Statistics, Wright State University Scholarly Activities:
2004-2008 Associate Professor, Dept of Mathematics & Statistics, Wright State Univ
2000-2004 Assistant Professor, Dept of Mathematics & Statistics, Wright State
1998-2000 Univ Lecturer, Department of Mathematics, University of Texas at Austin
1993-1998 Teaching Assistant, Department of Mathematics, Temple University
1988-1993 Assistant Professor, Department of Mathematics, Xiamen University
1986-1988 Lecturer, Department of Mathematics, Xiamen University

Scholarly Activities:
Publications: 18
Presentations and Invited Lectures: 36 Graduate Theses Directed: 1
Funding: $137,842 (from NSF in the past)

Publications: (10 recent)
Allen G. Hunt

**Personal Data:**
Address: Department of Physics, Wright State University, Dayton, OH, 45435
Telephone: (937) 775-3116; FAX (937) 775-2222; E-mail: allen.hunt@wright.edu

**Education:**
1995   M.A., Geology, Duke University
1983   Ph.D, Physics, University of California, Riverside
1980   M.S., Physics, University of California, Riverside

**Professional Activities & Awards:** Non-linear Processes in Geophysics, Editorial Board (2011-2014)
Program Committee, Non-linear Geophysics Focus Group, American Geophysical Union, 2011-
Reviewer for more than 20 journals in physics, hydrology, soil sciences, engineering. Nominated for
Hydrology Section Award, American Geophysical Union, 2003.

**Professional Career:**
2007- present Professor, Dept. of Physics, Wright State University
2004-2007 Associate Professor, Dept. of Physics, Wright State University
2002-2003 Program Director, National Science Foundation, Hydrologic Sciences
1999-2002 Visiting Faculty, Pacific Northwest National Laboratory, Climate Dynamics
1985-1987 Fulbright Scholar, Philipps Universitaet Marburg, FR Germany

**Scholarly Activities:**
Refereed Publications: 109 in 40 different journals, H-index 21 (ISI) 22 (Scholar)
Total Publications 170

Presentations and Invited Lectures: over 200
Graduate Dissertations and Theses Directed: 3
Funding: NSF, DOE, USDA, Phelps-Dodge, Pacific Northwest National Laboratory, BHP- Billiton,
Procter & Gamble, Helmholtz Research Center, Juelich, FRG, Fulbright Commission ($750,000;
$450,000 since arrival at Wright State University, 2004).
Publications: (10 recent)

Ion Juvina

Personal Data:
Address: Department of Psychology, Wright State University, Dayton, OH, 45435
Telephone: (937) 775-2391; Fax: (937) 775-3347; E-mail: ion.juvina@wright.edu

Education:
2009    Postdoc, Computational Cognitive Modeling, Carnegie Mellon University
2006    Ph.D, Information Science, Utrecht University
1995    B.S & M.S., Psychology, University of Bucharest

Professional Activities & Awards:
2014    Co-Chair of The 4th Annual Midwestern Cognitive Science Conference
2014    Program Board of The 8th International Conference on Augmented Cognition
2013    Organizing Committee of the AAAI symposium on Integrated Cognition
2005    Best Student Paper Award at the 10th International Conference on User Modeling

Professional Career:
2012 – present Assistant Professor, Dept. of Psychology, Wright State University

Scholarly Activities:
Publications: 14
Presentations and Invited Lectures: 33
Funding: $120,000 (in past 5 yrs.)

Publications: (10 recent)


Harry J. Khamis

**Personal Data:**
Address: Statistical Consulting Center, Wright State University, Dayton, OH. 45435
Telephone: (937) 775-2433; FAX (937) 775-2081; E-mail: harry.khamis@wright.edu

**Education:**
1980 Ph.D., Statistics, Virginia Tech
1976 M.S., Mathematics, Virginia Tech
1974 B.S., Mathematics, Santa Clara University

**Professional Activities & Awards:**
Director, Statistical Consulting Center since 1993
Editorial Board Member for 5 journals
Supervised two statistics Ph.D. students (Uppsala University, Sweden)
Joint appointment in the Boonshoft School of Medicine
Phi Beta Delta Honor Society for International Scholars (WSU)
Pi Delta Phi, la Société d’Honneur Française (WSU)
Delta Omega Honorary Society in Public Health (WSU)
Inductee, Wright Brothers Society (WSU)
Accredited Professional Statistician (PStat), American Statistical Association

**Professional Career:**
1993-present Professor, Dept. of Mathematics and Statistics, WSU
1986-1993 Associate Professor, Dept. of Mathematics and Statistics, WSU
1980-1986 Assistant Professor, Dept. of Mathematics and Statistics, WSU
Scholarly Activities:

Publications: 90

Presentations and Invited Lectures: 111
Graduate Dissertations and Theses (Ph.D.) Directed: 2
Funding: $496,685 as PI, $500,000 as Co-PI since 1982.

Publications: (10 recent)

GREGORY KOZLOWSKI

Personal Data:
Address: Dept. Physics, Wright State University Department
Telephone: (937) 775-3433; fax: (937) 775-2222; E-mail: Gregory.kozlowski@wright.edu

Education:
1964  M.Sc. Wroclaw University  Physics
1969  Ph.D Polish Academy of Sciences  Solid State Physics
1975  D.Sc Wroclaw University  Magnetism
1976/1977  Cambridge University  Superconductivity
2007/2008  Cambridge University  Nanotechnology

Professional Career:
1999-present  Assistant, Associate, and Full Professor (since 2010), Wright State University (WSU), Dayton, OH
1989-1999:  NRC Senior Fellow (AFRL); Research and Adjunct Associate Prof. (WSU)
1988-1989:  Senior Research Scientist, University of Houston, TX
1984-1988:  Assistant Professor, Wagner College, New York, NY
1983-1984:  Distinguished Professor, University of Alberta, Canada
1968-1983:  Professor, Chairman, Polish Academy of Sciences, Wroclaw, Poland
1964-1968:  Assistant Professor, Wroclaw University, Poland

Research Areas of Interest:
Evanescent Microwave Microscopy, Raman Spectroscopy, RF and microwave materials characterization, Optical properties of metallic and magnetic nanoparticles, Electromagnetic properties of carbon nanotube films and yarns, Electro-optical linear and nonlinear properties of novel materials, Metamaterials, Pulsed Laser Deposition technique, Hyperthermia, Supercapacitors

Publications (selected)


Dan E. Krane

**Personal Data:**
Address: Department of Biological Sciences, Wright State University, Dayton, OH, 45435
Telephone: (937) 775-2257; FAX (937) 775-3302; E-mail: Dan.Krane@wright.edu

**Education:**
1990 Ph.D, Biochemistry program of the Department of Molecular and Cell Biology, The Pennsylvania State University, University Park, PA
1985 B.S., in Biology and Chemistry at John Carroll University, University Heights, OH

**Professional Activities & Awards:**
College of Science and Math teacher of the year award, Wright State University, (1995, 1997 and 2008)


Co-investigator (Mike Raymer, PI): National Science Foundation (Computer Science Directorate) grant for $542,056 ($47,254 under the direct control of D. E. Krane) for “Crossing the interdisciplinary barrier: An integrated undergraduate program in bioinformatics.” (2001-2005).

Omicron Delta Kappa, Honorius Causa member, Wright State University Circle, National Leadership Honorary Society (2012)


**Professional Career:**
2013-present Affiliate Professor, Dept. of Computer Sciences, Wright State University

2011-present University Faculty President

2007-present Professor, Dept. of Biological Sciences, Wright State University

2002-present President and CEO of Forensic Bioinformatics, Inc.

2002-2007 Associate Professor, Dept. of Biological Sciences, Wright State University

1993-2000 Assistant Professor, Dept. of Biological Sciences, Wright State University
Scholarly Activities:

Publications: 51

Presentations and Invited Lectures: >100 since 1993
Graduate Dissertations and Theses Directed: 8
Funding: >$2,000,000 since 1993

Publications: (10 recent)


Gengxin Li

Personal Data:
Address: Department of Mathematics and Statistics, Wright State University

Telephone: (937) 775-4211; FAX (937) 775-2081; E-mail: gengxin.li@wright.edu

Education:
2010    Ph.D, Statistics, Michigan State University
2005    M.S., Statistics, Michigan State University
1997    B.S., Finance, Capital University of Economics and Business (China)

Professional Activities & Awards:
Recent Patents on Biotechnology, Editorial Board (2013 - )
Annals of Biometrics and Biostatistics, Editorial Board (2013 - )

Professional Career:
2012-present: Assistant Professor, Dept. of Mathematics and Statistics, Wright State University
2010-2012: Postdoc, Dept. of Biostatistics, Yale University.

Scholarly Activities:
Publications: 9
Presentations and Invited Lectures: 12

Publications:


Qun Li

**Personal Data:** Address: Department of Mathematics and Statistics, Wright State University
Telephone: (937) 775-4211; FAX (937) 775-2081; E-mail: qun.li@wright.edu

**Education:**

Ph.D. in Mathematics, May, 2008 McGill University, Canada Advisor: Pengfei Guan

Master of Science, August, 2003 McMaster University, Canada Advisor: Pengfei Guan

B.A. in Mathematics, July 2000 Qingdao University, P.R.China

**Professional Career:**

2009–present: Assistant Professor, Wright State University,
2008–Aug. 2009: Zassenhaus Assistant Professor, The Ohio State University.

**Scholarly Activities:**

11 invited talks.


**Publications:**


Yi Li

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Address: College of Science and Mathematics, Wright State University, Dayton, OH, 45435
Telephone: (937) 775-2611; FAX (937) 775-3068; E-mail: yi.li@wright.edu

Education:
1988 Ph.D, Mathematics, University of Minnesota
1982 B.S., Mathematics, Xi’an Jiaotong University

Professional Activities & Awards:
2013 Member of Class of the Institute for Management and Leadership in Education
(MLE), Harvard University
2008 Department received the Exemplary Program Award by the American
Mathematical Society (AMS) for its work in recruiting, mentoring and preparing doctoral
students from underrepresented U.S. minorities
2008 Sloan Foundation Special Recognition on “advancing underrepresented minority
students in mathematics, science and engineering”
2005 Presidential Award for Excellence in Science, Mathematics and Engineering
Mentoring (NSF-PAESMEM) to the Department of Mathematics, University of Iowa
2001 Sloan Foundation designated minority Ph.D. student mentor

Editorial Board of Chinese Journal of Mathematics (2013-present)
Editorial Board of Communications on Pure and Applied Analysis (2011-present)
Editorial Board of Discrete and Continuous Dynamical Systems Series S (2007-2011)
Editorial Board of ISRN Mathematical Analysis (2010-present)
Editorial Board of Journal of Applied Mathematics and Statistics (2013-present)
**Professional Career:**

2011-present Dean and Professor, College of Science and Mathematics, Wright State University

2007-2011 Chair, Department of Mathematics, University of Iowa

2005-2007 Director, Applied Mathematical and Computational Sciences, University of Iowa

2001-2005 Associate Chair, Director of Graduate Study, Department of Mathematics, University of Iowa

2001 Spring Acting Associate Chair, Director of Undergraduate Study, Department of Mathematics, University of Iowa

1999-2011 Professor, Department of Mathematics, University of Iowa

1996-1999 Associate Professor, Department of Mathematics, University of Iowa

1993-1997 Associate Professor, Department of Mathematics, University of Rochester

1989-1993 Assistant Professor, Department of Mathematics, University of Rochester

1988-1990 L.E. Dickson Instructor, Department of Mathematics, University of Chicago

1983-1988 Teaching Assistant, School of Mathematics, University of Minnesota

1982-1983 Instructor, Department of Mathematics, Xi'an Jiaotong University

**Scholarly Activities:**

Publications: over 90
Ph.D. Dissertations Directed: 10
Funding: over $1,000,000 (NSF & DoE in past 5 yrs.)

Profession-Conferences Organized on Research: numerous

Promotion & Tenure Review for Other Universities: numerous

Presentations and Invited Lectures: numerous

Ph.D. Dissertations Committee: numerous
Publications: (10 recent)


Ivan R. Medvedev

Personal Data:
Address: Department of Physics, Wright State University, Dayton, OH, 45435
Telephone: (937) 775-2561; E-mail: ivan.medvedev@wright.edu

Education:
2005 Ph.D, Physics, Ohio State University
1998 M.S., Physics, Moscow Institute of Physic and Technology, Moscow, Russia
1996 B.S., Physics, Moscow Institute of Physic and Technology, Moscow, Russia

Professional Activities & Awards:
Member of American Physical and Chemical Societies.

Professional Career:
2010 – present Assistant Professor, Dept. of Physics Wright State University
2011 – present Visiting Scholar, Ohio State University
2005 – 2010 Research Scientist, Ohio State University
2009 – 2010 Adjunct Faculty, Columbus State Community College

Scholarly Activities:
Publications: 42
Presentations and Invited Lectures: 63
Graduate Dissertations and Theses Directed: 1
Funding: $372k (in past 3 yrs.) (Samsung, ARMY, AFOSR, NAVI, MDA)
Publications: (10 recent)

Steen Pedersen

Personal Data:
Address: Department of Mathematics and Statistics, Wright State University, Dayton, OH 45435
Telephone: (937)775-2432; E-mail: steen@math.wright.edu

Education:

Professional Activities:
Editor for Far East Journal of Mathematical Sciences (FJMS) (0972-0871), for several years ending in 2011.

Professional Career:
1998-present Professor, Department of Mathematics and Statistics, Wright State University.
1992-1998 Associate Professor, Department of Mathematics and Statistics, Wright State University.
1988-1992 Assistant Professor, Department of Mathematics and Statistics, Wright State University.
1987-1988 Visiting Assistant Professor, Department of Mathematics, Indiana University- Purdue University Indianapolis.
1985-1987 Visiting Scholar, Department of Mathematics, University of Iowa.
1982-1985 Assistant Professor, Mathematics Institute, Aarhus University.

Scholarly Activities:
Publications: 48
Presentations and Invited Lectures: more than 100
Graduate Dissertations and Theses Directed: 1 (and 1 in progress) Funding: Approximately $94,000
Publications: (10 recent)

1. (with Palle Jorgensen and Feng Tian) Spectral theory of multiple intervals. Trans. AMS, accepted for publication, pages 1–61.
   From Calculus to Analysis, Springer Verlag, textbook, accepted for publication.
3. (with Jason D. Phillips) Exact Hausdorff Measure of Certain Non-Self-Similar Cantor Sets, Fractals 21 (2013), no. 3–4, 1350016
Douglas T. Petkie

Personal Data:
Address: Department of Physics, Wright State University, Dayton, OH, 45435
Telephone: (937) 775-2955; FAX (937) 775-2222; E-mail: doug.petkie@wright.edu

Education:
1996  Ph.D, Physics, The Ohio State University
1990  B.S., Physics, Carnegie Mellon University

Professional Activities & Awards:
Visiting Faculty, High Frequency Electronics, The Fraunhofer Institute for Applied Solid State Physics IAF, Freiburg, Germany, January-June 2010, WSU Sabbatical


NASA/ASEE Summer Faculty Fellowship, Molecular Spectroscopy Group, Jet Propulsion Laboratory, Summer of 1998


Program Committee Member for the Millimetre Wave and Terahertz Sensors and Technology Conference, SPIE Europe Security and Defense 2008-2010 Symposia


Member of the IEEE, APS, OSA, SPIE, and AAPT

Professional Career:
2013-current Chair and Associate Professor of Physics, Dept. of Physics, Wright State University
2012-2013 Interim Chair of Physics, Dept. of Physics, Wright State University
2008-2013 Associate Professor of Physics and Electrical Engineering, Dept. of Physics, Wright State University
2007-2008 Associate Professor of Physics, Dept. of Physics, Wright State University

2002-2007 Assistant Professor of Physics, Dept. of Physics, Wright State University

2001-2002 Associate Professor of Physics, Dept. of Physics, Ohio Northern University

1998-2001 Assistant Professor of Physics, Dept. of Physics, Ohio Northern University

1996-1998 Assistant Professor of Physics, Department of Science, Bluffton College

**Scholarly Activities:**

Publications: 35

Presentations and Invited Lectures: 50

Graduate Dissertations and Theses Directed: 8

Funding: $6M (in past 10 yrs.)

**Publications:** (10 recent)


Long Qu

Personal Data:
Address: Dept. of Mathematics & Statistics, Wright State University, Dayton, OH, 45435
Telephone: (937) 775-2183; FAX (513) 873-2081; E-mail: long.qu@wright.edu

Education:
2010  Ph.D, Statistics and Bioinformatics & Computational Biology, Iowa State University
2004  M.S.M.S., Occupational & Environmental Health, China Medical University
2002  B.Med., Clinical Medicine, China Medical University

Professional Activities & Awards:
Statistical Reviewer for Journal of the American Veterinary Medical Association (2013-), American Journal of Veterinary Research (2013-)


Professional Career:
2013-Present  Assistant Professor, Dept. of Mathematics and Statistics, Wright State University

Scholarly Activities:
Publications: 22
Invited Presentations: 10
Funding: $30,863.00 (NSF DMS in past 5 yrs.)

Publications: (10 recent)

Thomas E. Skinner

Personal Data:
Address: Department of Physics, Wright State University, Dayton, OH, 45435
Telephone: (937) 775-4549; FAX (937) 775-2222; E-mail: thomas.skinner@wright.edu

Education:
1985       Ph.D, Physics, The Johns Hopkins University
1980       M.A., Physics, The Johns Hopkins University
1976       B.A., Natural Sciences, The Johns Hopkins University

Professional Activities & Awards:
Invited Fellow, Kavli Institute of Theoretical Physics, University of California, Santa Barbara
(2009 Jun 14–Jul 18)
Member American Geophysical Union (1985-1989, 2012)
Member, Ultraviolet Spectroscopy team for the Galileo Mission to Jupiter, The Laboratory for
Atmospheric and Space Physics (1985-1988).
Physics, Magnetic Resonance in Chemistry
Reviewer for National Science Foundation, German Research Foundation
Departmental Merit Award, Physics, Johns Hopkins University (1976)

Professional Career:
2003-present  Professor, Dept. of Physics, Wright State University
1998-2003     Associate Professor, Dept. of Physics, Wright State University
1993-1998     Assistant Professor, Dept. of Physics, Wright State University
1990-1993     Research Scientist, Dept. of Radiology, Ohio State University, Columbus, Ohio
1988–1990     Postdoctoral Fellow, University of Colorado Health Sciences Center,
University of Colorado, Denver, Colorado
1985-1988     Research Associate, Laboratory for Atmospheric and Space Physics,
University of Colorado, Boulder, Colorado
1984-1985     Postdoctoral Fellow, Dept. of Physics and Astronomy, The Johns Hopkins
University, Baltimore, Maryland
Scholarly Activities:

Reviewed Publications: 63, h-index 20, average 19 citations/paper, 37 citations/year

Presentations and Invited Lectures: over 120

Graduate Dissertations and Theses Directed: 4

Funding: over $1,900,000 (Continual Funding from 35 NASA, NIH, NSF grants since 1984)

$726,426 from 4 NSF grants in past 5 years

Publications: (10 recent)


Daniel Slilaty

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Telephone: (937) 775-2572; FAX (513) 873-3301; E-mail: Daniel.slilaty@wright.edu

Education:
2000 Ph.D, Mathematics, Binghamton University
1997 M.S., Mathematics, University of Illinois
1993 B.S., Mathematics, Binghamton University

Professional Career:
2001-Present Professor, Dept. Math. and Stats., Wright State University
2007-2014 Associate Professor, Dept. Math. and Stats., Wright State University
2001-2007 Assistant Professor, Dept. Math. and Stats., Wright State University

Scholarly Activities:
Publications: 16
Presentations and Invited Lectures: 31
Graduate Dissertations and Theses Directed: 1
Funding: $35,000 Simons Foundation Collaboration Grant.

Publications:


Mohamed M. Sulman

Personal Data: Address: Dept. of Mathematics and Statistics, Wright State University, Dayton, OH
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Education:
2008 Simon Fraser University, Ph.D. in Applied Mathematics
2003 Simon Fraser University, M.Sc. in Applied Mathematics
2000 Tsinghua University, M.Sc. in Applied Mathematics
1993 El-Neelain University, B.Sc. in Mathematics

Professional Activities:
Reviewer for Journal of Computational Physics
Reviewer for Journal of Communications in Nonlinear Science and Numerical Simulation

Professional Experience:
Aug 2013–Present Assistant Professor, Department of Mathematics and Statistics, Wright State University
May 2011–Jul 2013 Associate Research Scientist, School of Marine Science and Policy, University of Delaware
Oct 2009 - May 2011 Visiting Assistant Professor, Dept. of Mathematical Sciences, Worcester Polytechnic Institute
Aug 2008 – Oct 2009 Postdoctoral Research Associate, Department of Mathematics, Simon Fraser University
May 2004 – Aug 2008 Research assistant and Ph.D. student, Dept. of Mathematics, Simon Fraser University

Recent publications:

Thaddeus Tarpey

Personal Data:
Address: Department of Mathematics & Statistics, Wright State University, Dayton, OH, 45435
Telephone: (937) 775-2861; FAX (513) 873-2801; E-mail: thaddeus.tarpey@wright.edu

Education:
1992 Ph.D, Mathematics Indiana University
1987 M.S., Mathematics, Indiana University
1983 B.S., Mathematics, University of Kentucky

Professional Activities & Awards:
Associate Editor, The American Statistician, 2007-present
Director of the Statistics Program, Wright State U., Dept. Math & Stats, 2009-2013

Professional Career:
2006-present Professor, Dept. of Mathematics and Statistics, Wright State University
2000-2006 Associate Professor, Dept. of Math & Stats, Wright State University
1994-2000 Assistant Professor, Dept. of Math & Stats, Wright State University
2001-2002 Senior Biostatistician, Columbia University & New York State Psychiatric Institute

Scholarly Activities:
Publications: 38
Invited Lectures: 22
Graduate Dissertations and Theses Directed: 0
PhD Committees (Member): 11

Funding:
- (Current) $521,884; NIH R01 MH095836 (role: co-Investigator), $22,621; NIH R01 MH099003 (role: co-Investigator), $102,177.
- (Past) NIH R01 MH068401 (role PI), 2005-2008,
Publications: (10 recent)


Weizhen Wang

Personal Data:
Address: Dept. of Mathematics and Statistics, Wright State University, Dayton, OH, 45435;
Telephone: (937) 775-2141; FAX (937) 775-2081; E-mail: weizhen.wang@wright.edu

Education:
1995 Ph.D., Statistics, Cornell University
1990 M.S., Probability, Peking University
1987 B.S., Mathematics, Peking University

Professional Career:
2007-present, Professor, Dept. of Mathematics and Statistics, Wright State University
2002-2007, Associate Professor, Dept. of Mathematics and Statistics, Wright State University
1996-2002, Assistant Professor, Dept. of Mathematics and Statistics, Wright State University

Scholarly Activities:
Publications: 32
Presentations and Invited Lectures: 32
Graduate Dissertations and Theses Directed: 0
Funding: $190,000 (Continual Funding from NSF Division of Mathematical Sciences since 2001), $102,811 (in past 5 yrs.)

Publications: (selected)

Xiangqian Zhou

Personal Data:
Address: Dept. of Mathematics and Statistics, Wright State University, Dayton, OH, 45435;
Telephone: (937) 775-4658; FAX (937) 775-2081; E-mail: xiangqian.zhou@wright.edu

Education:
2003 Ph.D. Mathematics Ohio State University
1998 B.S Mathematics University of Science and Technology of China

Professional Career:
2013-present Associate Professor, Dept. of Math and Stat, Wright State University
2008-2013 Assistant Professor, Dept. of Math and Stat, Wright State University
2007-2008 Assistant Professor, Dept. of Math, Marshall University
2006-2007 Visiting Professor, Dept. of Math, the University of Mississippi
2005-2006 Post-doc Fellow, Dept of Math, Syracuse University
2004-2005 Post-doc Fellow, Dept of Comb. Optimization, University of Waterloo

Scholarly Activities:
Publications: 15
Presentations and Invited Lectures: 25
Graduate Dissertations and Theses Directed: none
Funding: WSU Research Initiation Grant 2009, $9600

Publications: (10 recent)
December 18, 2013

Dean Yi Li
College of Science and Mathematics
3640 Colonel Glenn Highway
134 Oelman Hall
Wright State University
Dayton, OH 45435

Dean Li:

Thank you for your invitation to serve on the Advisory Board for Ph.D. program entitled “Interdisciplinary Applied Science and Mathematics”. The program is most interesting and I would be delighted to serve in that capacity.

The program appears to be well-aligned with the goals of the Center for Manufacturing Sciences (CMS) and I look forward to the collaboration with the College of Science and Mathematics.

Regards,

[Signature]

Dr. Larry R. Dossor
Senior Fellow for Technology Advancement
Director, Center for Manufacturing Sciences
Air Force Institute of Technology  
AFIT/ENR  
2950 Hobson Way  
Wright-Patterson AFB, OH  45433-7765  

2 January 2014

Dr. Yi Li  
Dean, College of Science and Mathematics  
Wright State University  
3640 Colonel Glenn Hwy  
Dayton, OH  45435-0001

Dear Dr. Li:

I am very pleased to accept your invitation to serve as a member of the Advisory Board for Wright State University’s proposed Ph.D. program in Interdisciplinary Applied Science and Mathematics.

I am looking forward to participating in this effort to develop an innovative curriculum of relevance to the Science, Technology, Engineering and Mathematics (STEM) initiatives of the Dayton region.

Sincerely,

[Signature]
Heidi R. Ries, PhD  
Dean for Research  
Graduate School of Engineering and Management

(937) 255-3636 ext 4544
Dear Dean Li

Thank you for inviting me to participate as a member of the Advisory Board for Wright State University’s new Applied Science and Mathematics doctoral program. I am truly flattered by the invitation and gladly accept. I have attached a copy of my curriculum vitae. I look forward to interacting with the Advisory Board.

Sincerely

MORLEY O. STONE, PhD, ST
Chief Scientist
711th Human Performance Wing
December 10, 2013

Re: Letter of Acceptance

Professor Yi Li, Dean
College of Science and Mathematics
Room 106 Oelman
3640 Colonel Glenn Hwy.
Wright State University
Dayton, Ohio 45435-0001

Dear Prof. Li,

Thank you very much for the letter dated November 27, 2013, asking me to become a member of the Advisory Board for the new Ph.D. program titled Interdisciplinary Science and Mathematics. The description of the curriculum in the attached document is comprehensive, for example, in focus area I titled Materials and Nanoscale Science and Technology.

I am delighted to accept your invitation, and look forward to work with you and the other Advisory Board members on curriculum design and program operation.

With best regards,
Sincerely,

R. Pachter
Ruth Pachter, Ph.D.
Air Force Research Laboratory, Materials & Manufacturing Directorate
AFRL/RX, Wright-Patterson Air Force Base, Ohio 45433-7702
ruth.pachter@us.af.mil

Attachment: short CV
December 11, 2013

Dr. Yi Li, Dean
College of Science and Mathematics
Wright State University

Dear Dr. Li:

I am honored by your letter of invitation, dated November 27, 2013, to serve on the Advisory Board for the Ph.D. program in Interdisciplinary Applied Science and Mathematics at Wright State University. I accept. I have enclosed a brief CV. I will respond to your request for preliminary advice at a later date; I have not read the PDP closely at this point in time.

Sincerely,

[Signature]

Paul Eloee, Ph.D.
Professor and Graduate Program Director
Department of Mathematics
University of Dayton
Peloe1@udayton.edu
In the following report, Hanover Research examines the feasibility of a new Ph.D. program in Interdisciplinary Applied Science and Mathematics. The report considers degree completion trends to approximate student demand, investigates the labor market outlook for graduates of the program, and profiles six similar doctoral programs offered at other institutions.
# TABLE OF CONTENTS

Executive Summary and Key Findings ................................................................................. 4  
  INTRODUCTION ................................................................................................................. 4  
  KEY FINDINGS ................................................................................................................. 5  

## Section I: Student Demand .......................................................................................... 7  
  DEGREE COMPLETIONS METHODOLOGY ................................................................... 7  
  NATIONAL DEGREE COMPLETIONS ............................................................................ 9  
  REGIONAL COMPLETION TRENDS ............................................................................ 11  
  STATE COMPLETION TRENDS .................................................................................. 13  
  ESTIMATED SUPPLY OF PROSPECTIVE STUDENTS ............................................. 14  
  INTERNATIONAL STUDENT DEMAND .................................................................... 19  

## Section II: Labor Market Outlook .............................................................................. 20  
  LABOR MARKET OUTLOOK METHODOLOGY ....................................................... 20  
  NATIONAL LABOR MARKET OUTLOOK .................................................................. 22  
  Additional National Indicators .............................................................................. 24  
  OHIO PROJECTIONS .................................................................................................. 25  
  REGIONAL EMPLOYERS ......................................................................................... 28  
  Air Force Research Laboratory .............................................................................. 28  
  Air Force Institute of Technology .......................................................................... 29  
  Other Ohio Employers ............................................................................................ 29  
  INTERNATIONAL RESEARCH .................................................................................. 31  

## Section III: Funding .................................................................................................. 32  
  FOUNDATION FUNDING ......................................................................................... 33  
  GOVERNMENT FUNDING ......................................................................................... 33  
    National Science Foundation .............................................................................. 33  
    Other Federal Programs (DoD, DoE, NIH) ............................................................ 34  
    Scholarships and Fellowship Support ................................................................. 35  

## Section IV: Profiles of Applied Science and Mathematics Programs at Other Institutions 36  
  METHODOLOGY ........................................................................................................ 36  
  THE UNIVERSITY OF MARYLAND ......................................................................... 37  
    Coursework ........................................................................................................... 38  
    Admissions ........................................................................................................... 39
Funding ............................................................................................................................ 39
THE COLLEGE OF WILLIAM AND MARY........................................................................... 40
Coursework...................................................................................................................... 40
Admissions ..................................................................................................................... 42
Funding ............................................................................................................................ 42
THE UNIVERSITY OF PENNSYLVANIA ........................................................................... 42
Coursework...................................................................................................................... 42
Admissions ..................................................................................................................... 44
NORTHWESTERN UNIVERSITY ....................................................................................... 45
Coursework...................................................................................................................... 45
Admissions ..................................................................................................................... 46
COLUMBIA UNIVERSITY ............................................................................................... 46
Coursework...................................................................................................................... 47
Admissions ..................................................................................................................... 47
THE UNIVERSITY OF CALIFORNIA, BERKELEY .......................................................... 48
Coursework...................................................................................................................... 48
Admissions ..................................................................................................................... 48
EXECUTIVE SUMMARY AND KEY FINDINGS

INTRODUCTION

Interdisciplinary science research, particularly in the applied sciences, will be critical to the world’s efforts to solve diverse problems. According to the American Association for the Advancement of Science (AAAS), “interdisciplinary research can no longer be an optional pursuit—it must be front and center in any discussion of the future of science.” The AAAS argues that critical solutions to many of the world’s problems can only come from collaborative efforts between experts in different scientific fields. The AAAS asserts that graduate students, in particular, will need to balance a deep expertise within one area of focus with a broad understanding of other scientific disciplines. Graduates will need to understand the techniques used in other disciplines, as well as be able to communicate effectively with experts in other fields. The transition toward a larger pool of interdisciplinary researchers is already well underway; the AAAS cites the National Science Foundation (NSF) Survey of Earned Doctorates, to which about one-quarter of survey respondents have reported integrating two or more research fields in their dissertation work over the past few years.

In a 2009 article, Jeffrey Grossman, then the executive director of the Center of Integrated Nanomechanical Systems at the University of California, Berkeley, argued that future scientific advances will require collaboration between researchers in basic and applied sciences. Grossman noted that one great invention, the transistor, was developed not only by a basic scientist and an applied scientist, but also a scientist with the broad knowledge to work in both fields. Such scientists, familiar with basic and applied sciences, may have a significant role to play in future scientific advancements.

Scott Fraser, Director of Science Initiatives at the University of Southern California, recently left a position at the California Institute of Technology to lead new efforts at USC to spur interdisciplinary scientific research. Fraser aptly states that true interdisciplinary research does not simply confine experts from disparate fields to a shared project, but instead relies on training these experts so that they understand the core issues and methods that pertain to a given problem. Students who are already versed in multiple sciences stand to adapt to this model more easily than experts who possess only limited understanding of fields outside their area of focus.

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2 Ibid., pp. 26-27.
A Ph.D. program in Interdisciplinary Applied Science and Mathematics will prepare researchers of the kind that the AAAS and scholars such as Grossman and Fraser call for. This report examines the feasibility of establishing such a program at Wright State University. The report first considers potential student demand for the program at the national, regional, and state levels. Then, we examine the labor market outlook for graduates of the program. The report concludes with a review of six similar programs offered at institutions across the country.

**Key Findings**

In general, indicators of demand for the proposed Interdisciplinary Applied Science and Mathematics program—including degree conferral trends and long-term employment projections—are positive. The following key findings emerged in our research:

- **With its proposed program, Wright State stands to take advantage of the lack of competing applied science and mathematics programs and fill an unmet need in the higher education landscape.** Few, if any, programs in applied science and mathematics identical to the program proposed by Wright State University currently exist. Current Ph.D. programs in applied mathematics or applied sciences generally encourage students to concentrate on a single scientific field rather than require study across multiple scientific disciplines. Additionally, literature indicates that an interdisciplinary approach to scientific research will be increasingly important to innovation in the United States.

- **Applied mathematicians and scientists can expect to see employment opportunities increase over the course of the decade from 2010 to 2020.** The U.S. Bureau of Labor Statistics projects that job prospects will be best for biomedical engineers, biochemists and biophysicists, and environmental engineers. The demand for biology-trained employees mirrors the national student demand for doctoral programs in bioinformatics and related fields. In Ohio, employers are projected to need 366 qualified science- and math-trained individuals to meet labor demand each year.

- **There is a steadily increasing supply of bachelor’s and master’s students in science and math fields to populate a new doctoral program.** Growth in doctoral conferrals in Ohio and neighboring states indicates demand for science and math programs in the area. In Ohio, students have shown particular interest in engineering-related doctoral programs, though growth in conferrals is strongest in mathematics. Biological sciences master’s students have increased faster than students of engineering, mathematics, or physical sciences, indicating growth of the pool of potential doctoral students in the field.

- **Demand for programs in applied mathematics and science—especially in biomathematics, bioinformatics, and computational biology—is increasing at the national, regional, and state levels.** While participation in such programs is low in Ohio, this is more likely due to a shortage of area institutions offering doctoral programs, rather than reflective of low student interest. Data reveal a clear sustained interest in applied science and mathematics fields from 2008 to 2012.
• An aging workforce presents significant opportunities for graduates of an applied science and mathematics program, nationally and locally. Although occupations of interest are slated to shrink in size over the next several years in Dayton, area employers will require approximately 133 new qualified employees trained in science and mathematics each year through 2018. Slow rates of growth across most occupations are still associated with high levels of annual job openings.

• The U.S. government provides substantial funding for interdisciplinary and applied science programs in the form of National Science Foundation, National Institutes of Health, and National Institute of Standards and Technology grants. Academic programs may also seek funding through strategic partnerships with local industries or government facilities within the local geographic region, or national foundations interested in funding STEM programming and research.
SECTION I: STUDENT DEMAND

This section seeks to estimate potential student demand for a Ph.D. program in Interdisciplinary Applied Science and Mathematics. We consider five-year degree completion trends to gauge potential demand in the United States, as well as anecdotal evidence from abroad that hints at international demand.

DEGREE COMPLETIONS METHODOLOGY

To approximate student demand for interdisciplinary applied science and mathematics programs, we examine historical trends in doctoral degree completions in similar programs. We gathered these data from the Integrated Postsecondary Education Data System (IPEDS), a survey database managed by the National Center for Education Statistics (NCES). The NCES classifies academic programs based on the Classification of Instructional Programs (CIP), a taxonomic system that assigns two-, four-, and six-digit numeric codes to different academic programs to facilitate reporting and analysis by field of study. The IPEDS database contains degree completion data classified and submitted by all U.S. institutions of higher education.5

The NCES does not classify applied science and mathematics as a standalone discipline. In order to estimate demand for such an interdisciplinary program, we considered data for ten related disciplines. Figure 1.1 presents the six-digit CIP code, as well as the title and description published by the NCES, for each of the selected program categories. To retain emphasis on the broad, interdisciplinary nature of the proposed Interdisciplinary Applied Science and Mathematics program, the remainder of this report considers the four specialized biology-related fields (Biometry/Biometrics, Biostatistics, Bioinformatics, and Computational Biology), combined with the general category of Biomathematics, Bioinformatics, and Computational Biology, Other, as a single category. Combined, these fields represent the four-digit CIP code 26.11 – Biomathematics, Bioinformatics, and Computational Biology. We additionally consider three engineering CIP categories – Engineering Mechanics, Engineering Physics, and Engineering Science – that focus on applied engineering principles. The other CIP categories considered in this section are Applied Mathematics, General (CIP 27.0301) and Computational Mathematics (CIP 27.0303).

Figure 1.1: CIP Codes and Descriptions of Programs Selected for Analysis

<table>
<thead>
<tr>
<th>CIP Code</th>
<th>Field</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.1101</td>
<td>Engineering Mechanics</td>
<td>A program with a general focus on the application of the mathematical and scientific principles of classical mechanics to the analysis and evaluation of the behavior of structures, forces and materials in engineering problems. Includes instruction in statics, kinetics, dynamics, kinematics, celestial mechanics, stress and failure, and electromagnetism.6</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>CIP CODE</th>
<th>FIELD</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.1201</td>
<td>Engineering Physics/Applied Physics</td>
<td>A program focusing on the use of physics principles in the analysis and evaluation of engineering problems and other scientific applications. Includes instruction in high- and low-temperature phenomena, computational physics, superconductivity, applied thermodynamics, molecular and particle physics applications, and space science research.(^7)</td>
</tr>
<tr>
<td>14.1301</td>
<td>Engineering Science</td>
<td>A program with a general focuses on the general application of various combinations of mathematical and scientific principles to the analysis and evaluation of engineering problems, including applied research in human behavior, statistics, biology, chemistry, the earth and planetary sciences, atmospherics and meteorology, and computer applications.(^8)</td>
</tr>
<tr>
<td>26.1101</td>
<td>Biometry/Biometrics</td>
<td>A program that focuses on the application of statistics and other computational methods to the study of problems in the biological sciences and related fields in agriculture and natural resources. Includes instruction in computational biology, mathematical statistics, matrix algebra, applied calculus, experimental design, linear modeling, sampling theory, stochastic processes, spatial and temporal analysis, longitudinal analysis, sparse/unbalanced data and complex error, and applications to such topics as population genetics, animal breeding, forest genetics, population dynamics, wildlife biometry, ecology, and agricultural and natural resource management.(^9)</td>
</tr>
<tr>
<td>26.1102</td>
<td>Biostatistics</td>
<td>A program that focuses on the application of descriptive and inferential statistics to biomedical research and clinical, public health, and industrial issues related to human populations. Includes instruction in mathematical statistics, modeling, clinical trials methodology, disease and survival analysis, longitudinal analysis, missing data analysis, spatial analysis, computer tomography, biostatistics consulting, and applications to such topics as genetics, oncology, pharmacokinetics, physiology, neurobiology, and biophysics.(^10)</td>
</tr>
<tr>
<td>26.1103</td>
<td>Bioinformatics</td>
<td>A program that focuses on the application of computer-based technologies and services to biological, biomedical, and biotechnology research. Includes instruction in algorithms, network architecture, principles of software design, human interface design, usability studies, search strategies, database management and data mining, digital image processing, computer graphics and animation, CAD, computer programming, and applications to experimental design and analysis and to specific quantitative, modeling, and analytical studies in the various biological specializations.(^11)</td>
</tr>
<tr>
<td>26.1104</td>
<td>Computational Biology</td>
<td>A program that focuses on computational theoretical approaches to understanding biological systems, including computational models of biological processes, computational management of large-scale projects, database development and data-algorithm development, and high-performance computing, as well as statistical and mathematical analyses.</td>
</tr>
<tr>
<td>26.1199</td>
<td>Biomathematics, Bioinformatics, Computational Biology, Other</td>
<td>Any instructional program in biomathematics, bioinformatics, or computational biology not listed above.</td>
</tr>
<tr>
<td>27.0301</td>
<td>Applied Mathematics, General</td>
<td>A program that focuses on the application of mathematics and statistics to the solution of functional problems in fields such as engineering and the applied sciences. Includes instruction in natural phenomena modeling continuum mechanics, reaction-diffusion, wave propagation, dynamic systems, numerical analysis, controlled theory, asymptotic methods, variation, optimization theory, inverse problems, and applications to specific scientific and industrial topics.(^12)</td>
</tr>
</tbody>
</table>

In addition to the raw degree completion numbers, the tables presented in this section include three metrics to highlight annualized trends:

- The first measure, the **compound annual growth rate (CAGR)**, provides a “smoothed” measurement of annual growth; in other words, it disregards year-to-year fluctuations in the data and instead provides an indication of overall five-year growth.
- The second measure, the **average annual change (AAC)**, provides the average number by which completions rose or fell annually. This figure offers an indication of the raw magnitude of growth.
- Lastly, the **standard deviation of annual changes** gauges the volatility of annual growth. The larger the standard deviation of annual changes, the less consistent the growth from one year to the next. Inconsistent growth may reflect either annual fluctuations or the accelerating growth or decline of conferrals in a particular field.

At the time of completion of this report’s previous version, the NCES had not yet released final degree completion data for academic year 2011-2012. At the time of update, final data have been released; tables throughout this section reflect a new study period of 2008-2012.

**National Degree Completions**

Figure 1.2 presents national degree completion data for the four fields discussed above, while Figure 1.3 provides a graphic illustration of the growth trends in each field. **In general, degree completion trends indicate that student demand for doctoral degrees in fields related to applied science and mathematics is on the rise nationally.** The strongest average annual growth occurred for Computational Mathematics, in which doctoral completions grew by an average of 19.6 percent each year. However, the field is the only of the group to experience a negative average change in total conferrals and a negative CAGR, indicating that conferral levels are not reliable year to year. Doctoral conferrals in the three selected engineering fields grew at an average of 7.9 percent, with a compound annual growth rate of 6.0 percent, although total completions dropped significant from 2011 (236) to 2012 (193). The Bioinformatics-related fields grew significantly over the five-year study period, increasing an average of 10 students per year for a compound annual growth rate of 5.7 percent. Applied Mathematics saw moderate growth compared to the other three field groups.

---

Examsdining the data graphically, we see that while there is some internal volatility from year to year, each field has experienced overall increases, with the exception of Computational Mathematics.

The annual Survey of Earned Doctorates, published by the National Science Foundation (NSF), also suggests growing demand for doctoral programs in disciplines related to applied science and mathematics. The NSF survey uses slightly different categories than the
NCES, though similarities in the two classification methods allow the NSF categories to be loosely matched with the NCES-defined CIP codes. According to the NSF data, Bioinformatics has seen the greatest growth since 2007 (14 percent annually), followed by Engineering Physics (12.5 percent annually). All mathematics-related fields have seen greater growth in doctoral conferrals (3.7 percent annually) than all biology-related fields (3 percent annually) and all engineering-related fields (0.8 percent annually). The largest number of doctoral degrees has been granted in the field of Applied Mathematics (1,910 in five years). Overall, the data reveal reliable growth in doctoral conferrals amongst applied science and mathematics-related fields.¹⁴

![Figure 1.4: National Science Foundation, Doctorate Recipients by Subfield](image)

<table>
<thead>
<tr>
<th>FIELD</th>
<th>CONFERRAL YEAR</th>
<th>CAGR</th>
<th>AAC</th>
<th>STANDARD DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering (all subfields)</td>
<td>7,749 7,864 7,643 7,549 8,004</td>
<td>0.8%</td>
<td>63.8</td>
<td>255.8</td>
</tr>
<tr>
<td>Engineering mechanics</td>
<td>56 60 63 46 63</td>
<td>3.0%</td>
<td>1.8</td>
<td>12.2</td>
</tr>
<tr>
<td>Engineering physics</td>
<td>20 26 31 31 32</td>
<td>12.5%</td>
<td>3.0</td>
<td>2.5</td>
</tr>
<tr>
<td>Engineering science</td>
<td>43 35 42 52 52</td>
<td>4.9%</td>
<td>2.3</td>
<td>6.9</td>
</tr>
<tr>
<td>Biological, biomedical sciences (all subfields)</td>
<td>7,238 7,797 8,025 8,048 8,135</td>
<td>3.0%</td>
<td>224.3</td>
<td>207.0</td>
</tr>
<tr>
<td>Bioinformatics</td>
<td>83 147 175 123 140</td>
<td>14.0%</td>
<td>14.3</td>
<td>42.0</td>
</tr>
<tr>
<td>Biometrics and biostatistics</td>
<td>120 122 115 127 137</td>
<td>3.4%</td>
<td>4.3</td>
<td>7.5</td>
</tr>
<tr>
<td>Computational biology</td>
<td>- - - - 69 65</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mathematics (all subfields)</td>
<td>1,388 1,400 1,553 1,590 1,607</td>
<td>3.7%</td>
<td>54.8</td>
<td>57.5</td>
</tr>
<tr>
<td>Applied mathematics</td>
<td>334 360 382 401 433</td>
<td>6.7%</td>
<td>24.8</td>
<td>4.9</td>
</tr>
</tbody>
</table>

Source: National Science Foundation

**Regional Completion Trends**

Figures 1.5 and 1.6 present degree conferral data for the broader region, defined as Ohio and five bordering states (Indiana, Kentucky, Michigan, Pennsylvania, and West Virginia). The regional trends show that demand for doctoral programs in applied science and mathematics is growing regionally, though with significantly more annual volatility than seen at the national level. Biomathematics, Bioinformatics, and Computational Biology completions increased by 12.8 percent annually, and completions in Applied Mathematics increased 5.1 percent annually. These fields also demonstrate the greatest average annual

increase in the number of completions of the group. Completions in the selected Engineering fields grew at a slower pace in the region than seen at the national level, increasing by just 1.7 percent annually for a net increase of two students in 2012 over 2008 levels. Very few Computational Mathematics doctoral degrees were completed between 2008 and 2012 in the region, and IPEDS reports no Computational Mathematics completions for 2011.\textsuperscript{15}

Figure 1.5: Completion of Doctoral Degrees in Applied Science and Mathematics and Related Fields in Ohio and Neighboring States, 2008-2012

<table>
<thead>
<tr>
<th>CIP</th>
<th>FIELD</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>CAGR</th>
<th>AAC</th>
<th>STANDARD DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.1101, 14.1201, 14.1301</td>
<td>Engineering Mechanics, Engineering Physics, and Engineering Science</td>
<td>28</td>
<td>20</td>
<td>35</td>
<td>46</td>
<td>30</td>
<td>1.7%</td>
<td>0.5</td>
<td>12.9</td>
</tr>
<tr>
<td>26.1101, 26.1102, 26.1103, 26.1104, 26.1199</td>
<td>Biomathematics, Bioinformatics, and Computational Biology</td>
<td>34</td>
<td>36</td>
<td>48</td>
<td>42</td>
<td>55</td>
<td>12.8%</td>
<td>5.3</td>
<td>7.8</td>
</tr>
<tr>
<td>27.0301</td>
<td>Applied Mathematics, General</td>
<td>18</td>
<td>14</td>
<td>11</td>
<td>13</td>
<td>22</td>
<td>5.1%</td>
<td>1.0</td>
<td>5.1</td>
</tr>
<tr>
<td>27.0303</td>
<td>Computational Mathematics</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>18.9%</td>
<td>0.3</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Source: IPEDS

The lack of discernible average trends in conferrals amongst these fields is particularly evident when viewing the data graphically, as presented below. However, the significant increase in conferrals in Biomathematics, Bioinformatics, and Computational Biology is clearly evident. Engineering fields experienced a surge of student interest through 2011, losing some ground in the most recent data year.

\textsuperscript{15} NCES, Op. cit.
STATE COMPLETION TRENDS

Degree completion data for the state of Ohio, illustrated in Figures 1.7 and 1.8, reveal that very few students in Ohio pursue doctoral degrees in disciplines related to applied science and mathematics. This lack of participation, however, may reflect the absence of applied science and mathematics programs in Ohio, rather than a lack of student demand for such programs. Only six Ohio institutions report conferrals in the selected programs between 2008 and 2012, with the University of Toledo conferring the largest share of doctorates. No Ohio institution reported conferrals in any of the selected fields in 2011. IPEDs did not report any completions for Biometry/Biometrics, Bioinformatics, Computational Biology, or Computational Mathematics in Ohio over the five year period.

Despite a total decline in the number of conferrals from 2008 to 2012, data reveal a surge of interest in the selected Engineering fields from 2008 to 2010, representing compound average growth of 19 percent. The subsequent decline is partially due to the apparent and unexplained lack of data for 2011. Interest in Biostatistics peaked in 2010, returning to 2008 levels by 2012. Conferrals in Applied Mathematics similarly reached their highest level in 2010.
Table 1.7: Completion of Doctoral Degrees in Applied Science and Mathematics and Related Fields, Ohio, 2008-2012

<table>
<thead>
<tr>
<th>FIELD</th>
<th>CIP</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>CAGR</th>
<th>AAC</th>
<th>STANDARD DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>26.1102</td>
<td>Biostatistics</td>
<td>1</td>
<td>3</td>
<td>8</td>
<td>0</td>
<td>1</td>
<td>0.0%</td>
<td>0.0</td>
<td>4.8</td>
</tr>
<tr>
<td>27.0301</td>
<td>Applied Mathematics, General</td>
<td>4</td>
<td>2</td>
<td>8</td>
<td>0</td>
<td>3</td>
<td>-6.9%</td>
<td>-0.3</td>
<td>5.3</td>
</tr>
</tbody>
</table>

Source: IPEDS

Graphically the lack of data for 2011 is evident. While each of the three fields experienced net declines in the number of conferrals across Ohio, there is a background level of student interest which IPEDS data may not fully capture, as conferrals have been highly unpredictable.

Figure 1.8: Ohio Doctoral Degree Completion Trends in Applied Science and Mathematics and Related Fields, 2008-2012

Source: IPEDS

**Estimated Supply of Prospective Students**

Because the potential demand for applied science and mathematics doctoral degrees is largely dependent upon the supply of students graduating with bachelor’s and, to a larger extent, master’s degrees, it is useful to examine degree conferral rates at each level. We here examine historical trends within bachelor’s, master’s, and doctoral conferrals for four general degree fields: Engineering (CIP 14.0000), Biological Sciences (CIP 26.0000), Mathematics and Statistics (CIP 27.0000), and Physical Sciences (CIP 40.0000). We are most interested in bachelor’s- and master’s-level conferrals as a method of estimating potential student supply. To contextualize our findings appropriately, we examine doctoral conferrals.
and compare the rate of conferral growth at each level. As with our prior analysis, we present degree conferral data at the national, regional, and state levels. While in previous figures within this section we have provided average annual change in student numbers and standard deviations for such data, here we disregard these data. Such numbers in the datasets below would be so large as to be meaningless to the consideration of a single program. Instead, we provide the compound annual growth rate and the average annual rate of change, an indicator of growth which takes into account annual fluctuations.

At the national level (shown in Figure 1.9 on page 16), the four fields of interest have experienced steady growth across the 11-year study period at each degree level. Biological Sciences and Mathematics and Statistics saw greater growth amongst master’s conferrals than doctoral conferrals, indicating growth of the pool of students qualified to pursue a PhD. The number of doctoral students in all fields is smaller than that of either bachelor’s or master’s degree students, as would be expected. The gap between doctoral and other students in 2012 is greater amongst Mathematics and Statistics students than the other three fields. Notably, there is a relatively small gap between the number of Physical Science PhDs conferred in 2012 and the number of master’s degrees in the same field: none of the three other fields demonstrate this close of a relationship between conferrals at these levels. Overall, the data presented below indicate that there is significant and growing demand for graduate education in fields related to Applied Science and Mathematics, and students continue to be interested in doctoral-level studies across these fields.

Across Wright State University’s immediate geographical region consisting of Ohio and its border states, growth in doctoral conferrals outpaces growth in bachelor’s and master’s conferrals in all four broad fields considered in Figure 1.10 on page 17. This indicates a rising interest in pursuing doctoral studies within this six-state region. The gap between growth in bachelor’s and master’s conferrals and doctoral conferrals is particularly notable within Mathematics and Statistics, indicating that regional universities are increasingly a draw for students aiming to pursue a PhD in a math-related discipline. While bachelor’s conferrals in Engineering fields see the slowest rate of growth in the group, the field also sees the highest sheer number of students receiving degrees year to year. This is true at the master’s and doctoral level as well. So, while interest in Engineering may not be growing in the region as quickly as in other fields, there is significant potential in the number of students qualified each year to pursue a PhD.

Trends in conferrals from Ohio institutions mirror those seen across the broader six-state region. Over the 11-year study period, doctoral conferral rates in Ohio outpace those for bachelor’s and master’s degrees in nearly every field (Engineering excepted). These state-level findings are presented in Figure 1.11 on page 18. Again, growth of doctoral degrees is strongest amongst Mathematics and Statistics fields (7.7 percent), followed closely by doctoral conferrals in Biological Sciences (7.6 percent). Ultimately, however, few students pursue doctoral degrees in Mathematics and Statistics each year—an average of 40 students per year since 2002, compared to Engineering’s 321, Biological Sciences’ 225, and Physical Sciences’ 192. In Ohio there is a greater preference for graduate study of sciences over mathematics, though a growing interest in mathematics is present.
### Figure 1.9: National Supply of Science and Math Graduates, 2002-2012

<table>
<thead>
<tr>
<th>FIELD</th>
<th>LEVEL</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>CAGR</th>
<th>Annual Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering</td>
<td>BS</td>
<td>60,945</td>
<td>64,378</td>
<td>65,603</td>
<td>66,789</td>
<td>68,796</td>
<td>68,910</td>
<td>70,380</td>
<td>71,052</td>
<td>74,490</td>
<td>78,151</td>
<td>83,353</td>
<td>2.3%</td>
<td>3.2%</td>
</tr>
<tr>
<td></td>
<td>MS</td>
<td>26,122</td>
<td>28,793</td>
<td>32,800</td>
<td>33,147</td>
<td>31,693</td>
<td>29,877</td>
<td>32,412</td>
<td>35,777</td>
<td>36,131</td>
<td>39,435</td>
<td>41,508</td>
<td>3.8%</td>
<td>4.9%</td>
</tr>
<tr>
<td></td>
<td>PhD</td>
<td>5,188</td>
<td>5,287</td>
<td>5,931</td>
<td>6,562</td>
<td>7,430</td>
<td>8,092</td>
<td>8,157</td>
<td>7,986</td>
<td>7,751</td>
<td>8,406</td>
<td>8,777</td>
<td>4.5%</td>
<td>5.5%</td>
</tr>
<tr>
<td>Biological Sciences</td>
<td>BS</td>
<td>63,005</td>
<td>62,779</td>
<td>63,999</td>
<td>67,347</td>
<td>72,020</td>
<td>78,111</td>
<td>80,855</td>
<td>83,826</td>
<td>93,752</td>
<td>100,066</td>
<td>3.7%</td>
<td>4.8%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MS</td>
<td>6,189</td>
<td>7,004</td>
<td>7,691</td>
<td>8,219</td>
<td>8,738</td>
<td>8,805</td>
<td>9,621</td>
<td>9,963</td>
<td>11,425</td>
<td>12,523</td>
<td>3.4%</td>
<td>7.4%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PhD</td>
<td>4,430</td>
<td>4,985</td>
<td>5,226</td>
<td>5,606</td>
<td>5,805</td>
<td>6,379</td>
<td>6,965</td>
<td>7,031</td>
<td>7,419</td>
<td>8,032</td>
<td>2.9%</td>
<td>6.2%</td>
<td></td>
</tr>
<tr>
<td>Mathematics and Statistics</td>
<td>BS</td>
<td>13,770</td>
<td>14,061</td>
<td>15,118</td>
<td>16,236</td>
<td>16,773</td>
<td>17,059</td>
<td>17,218</td>
<td>17,664</td>
<td>18,370</td>
<td>19,973</td>
<td>21,940</td>
<td>3.4%</td>
<td>4.8%</td>
</tr>
<tr>
<td></td>
<td>MS</td>
<td>3,470</td>
<td>3,623</td>
<td>4,220</td>
<td>4,496</td>
<td>4,781</td>
<td>4,928</td>
<td>5,029</td>
<td>5,252</td>
<td>5,681</td>
<td>5,907</td>
<td>6,292</td>
<td>5.0%</td>
<td>6.2%</td>
</tr>
<tr>
<td></td>
<td>PhD</td>
<td>959</td>
<td>1,007</td>
<td>1,061</td>
<td>1,177</td>
<td>1,296</td>
<td>1,353</td>
<td>1,362</td>
<td>1,538</td>
<td>1,600</td>
<td>1,593</td>
<td>1,674</td>
<td>4.7%</td>
<td>5.8%</td>
</tr>
<tr>
<td>Physical Sciences</td>
<td>BS</td>
<td>19,170</td>
<td>19,167</td>
<td>19,413</td>
<td>20,387</td>
<td>21,684</td>
<td>22,464</td>
<td>23,281</td>
<td>23,985</td>
<td>24,861</td>
<td>26,249</td>
<td>28,173</td>
<td>2.9%</td>
<td>3.9%</td>
</tr>
<tr>
<td></td>
<td>MS</td>
<td>5,045</td>
<td>5,164</td>
<td>5,574</td>
<td>5,782</td>
<td>6,020</td>
<td>5,852</td>
<td>5,988</td>
<td>5,739</td>
<td>6,106</td>
<td>6,392</td>
<td>6,942</td>
<td>2.2%</td>
<td>3.3%</td>
</tr>
<tr>
<td></td>
<td>PhD</td>
<td>3,810</td>
<td>3,865</td>
<td>3,825</td>
<td>4,122</td>
<td>4,504</td>
<td>4,856</td>
<td>4,825</td>
<td>5,063</td>
<td>5,089</td>
<td>5,318</td>
<td>5,399</td>
<td>3.1%</td>
<td>3.6%</td>
</tr>
</tbody>
</table>

Source: IPEDS
Figure 1.10: Regional Supply of Science and Math Graduates, 2002-2012

| FIELD                  | LEVEL | 2002  | 2003  | 2004  | 2005  | 2006  | 2007  | 2008  | 2009  | 2010  | 2011  | 2012  | CAGR  | AVERAGE |
|------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|         |
|                        |       |       |       |       |       |       |       |       |       |       |       |       |       | ANNUAL CHANGE |
| Engineering            | BS    | 13,201| 13,670| 13,450| 13,575| 13,768| 13,702| 13,994| 14,004| 14,734| 15,123| 15,860| 1.2%  | 1.9%    |
|                        | MS    | 5,000 | 5,326 | 5,915 | 5,877 | 5,840 | 5,425 | 5,599 | 5,721 | 5,641 | 6,412 | 6,966 | 2.3%  | 3.5%    |
|                        | PhD   | 1,008 | 1,042 | 1,064 | 1,273 | 1,442 | 1,499 | 1,556 | 1,499 | 1,504 | 1,531 | 1,587 | 3.9%  | 4.8%    |
| Biological Sciences    | BS    | 9,999 | 9,848 | 9,981 | 10,159| 10,929| 11,854| 12,166| 12,512| 13,949| 14,405| 15,258| 3.4%  | 4.4%    |
|                        | MS    | 880   | 1,115 | 1,250 | 1,474 | 1,413 | 1,448 | 1,586 | 1,611 | 1,727 | 1,743 | 2,049 | 6.4%  | 9.2%    |
|                        | PhD   | 491   | 732   | 781   | 795   | 881   | 890   | 964   | 1,073 | 1,134 | 1,194 | 1,201 | 8.4%  | 10.1%   |
| Mathematics and Statistics | BS   | 2,357 | 2,375 | 2,654 | 2,839 | 2,832 | 2,993 | 3,013 | 2,912 | 3,192 | 3,403 | 3,790 | 3.4%  | 5.0%    |
|                        | MS    | 622   | 624   | 716   | 793   | 810   | 763   | 780   | 811   | 791   | 892   | 945   | 3.3%  | 4.5%    |
|                        | PhD   | 148   | 176   | 170   | 192   | 221   | 203   | 213   | 271   | 257   | 255   | 278   | 5.1%  | 7.1%    |
| Physical Sciences      | BS    | 3,693 | 3,668 | 3,594 | 3,724 | 3,990 | 4,129 | 4,195 | 4,155 | 4,637 | 4,842 | 5,097 | 2.5%  | 3.3%    |
|                        | MS    | 815   | 878   | 899   | 940   | 923   | 999   | 921   | 865   | 892   | 930   | 1,036 | 1.2%  | 2.6%    |
|                        | PhD   | 634   | 621   | 604   | 642   | 700   | 745   | 790   | 783   | 824   | 861   | 848   | 2.8%  | 3.0%    |

Source: IPEDS
### Figure 1.11: Ohio Supply of Science and Math Graduates, 2002-2012

<table>
<thead>
<tr>
<th>FIELD</th>
<th>LEVEL</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>CAGR</th>
<th>AVG ANNUAL CHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Engineering</strong></td>
<td><strong>BS</strong></td>
<td>2,572</td>
<td>2,728</td>
<td>2,868</td>
<td>2,762</td>
<td>2,964</td>
<td>2,795</td>
<td>2,715</td>
<td>2,730</td>
<td>3,115</td>
<td>3,369</td>
<td>3,554</td>
<td>2.5%</td>
<td>3.5%</td>
</tr>
<tr>
<td></td>
<td><strong>MS</strong></td>
<td>1,089</td>
<td>1,100</td>
<td>1,241</td>
<td>1,297</td>
<td>1,549</td>
<td>1,301</td>
<td>1,307</td>
<td>1,331</td>
<td>1,269</td>
<td>1,556</td>
<td>1,718</td>
<td>3.3%</td>
<td>5.2%</td>
</tr>
<tr>
<td></td>
<td><strong>PhD</strong></td>
<td>260</td>
<td>226</td>
<td>258</td>
<td>302</td>
<td>365</td>
<td>327</td>
<td>387</td>
<td>330</td>
<td>364</td>
<td>354</td>
<td>362</td>
<td>2.8%</td>
<td>4.2%</td>
</tr>
<tr>
<td><strong>Biological Sciences</strong></td>
<td><strong>BS</strong></td>
<td>2,391</td>
<td>2,332</td>
<td>2,285</td>
<td>2,301</td>
<td>2,473</td>
<td>2,711</td>
<td>2,633</td>
<td>2,967</td>
<td>3,013</td>
<td>3,284</td>
<td>3,477</td>
<td>2.9%</td>
<td>4.0%</td>
</tr>
<tr>
<td></td>
<td><strong>MS</strong></td>
<td>225</td>
<td>220</td>
<td>273</td>
<td>283</td>
<td>300</td>
<td>272</td>
<td>331</td>
<td>303</td>
<td>366</td>
<td>378</td>
<td>468</td>
<td>4.8%</td>
<td>8.3%</td>
</tr>
<tr>
<td></td>
<td><strong>PhD</strong></td>
<td>130</td>
<td>176</td>
<td>179</td>
<td>187</td>
<td>186</td>
<td>200</td>
<td>267</td>
<td>277</td>
<td>294</td>
<td>292</td>
<td>286</td>
<td>7.6%</td>
<td>8.9%</td>
</tr>
<tr>
<td><strong>Mathematics and Statistics</strong></td>
<td><strong>BS</strong></td>
<td>432</td>
<td>434</td>
<td>477</td>
<td>506</td>
<td>467</td>
<td>571</td>
<td>490</td>
<td>455</td>
<td>526</td>
<td>558</td>
<td>651</td>
<td>2.4%</td>
<td>4.8%</td>
</tr>
<tr>
<td></td>
<td><strong>MS</strong></td>
<td>176</td>
<td>192</td>
<td>226</td>
<td>245</td>
<td>231</td>
<td>207</td>
<td>211</td>
<td>238</td>
<td>212</td>
<td>240</td>
<td>218</td>
<td>2.9%</td>
<td>2.7%</td>
</tr>
<tr>
<td></td>
<td><strong>PhD</strong></td>
<td>26</td>
<td>23</td>
<td>28</td>
<td>32</td>
<td>42</td>
<td>40</td>
<td>35</td>
<td>52</td>
<td>56</td>
<td>59</td>
<td>47</td>
<td>7.7%</td>
<td>8.0%</td>
</tr>
<tr>
<td><strong>Physical Sciences</strong></td>
<td><strong>BS</strong></td>
<td>772</td>
<td>788</td>
<td>776</td>
<td>747</td>
<td>736</td>
<td>846</td>
<td>773</td>
<td>776</td>
<td>865</td>
<td>902</td>
<td>1,003</td>
<td>1.4%</td>
<td>1.9%</td>
</tr>
<tr>
<td></td>
<td><strong>MS</strong></td>
<td>248</td>
<td>271</td>
<td>238</td>
<td>243</td>
<td>244</td>
<td>282</td>
<td>226</td>
<td>244</td>
<td>220</td>
<td>215</td>
<td>272</td>
<td>-1.3%</td>
<td>1.8%</td>
</tr>
<tr>
<td></td>
<td><strong>PhD</strong></td>
<td>169</td>
<td>180</td>
<td>163</td>
<td>174</td>
<td>211</td>
<td>189</td>
<td>222</td>
<td>186</td>
<td>222</td>
<td>208</td>
<td>214</td>
<td>1.9%</td>
<td>3.2%</td>
</tr>
</tbody>
</table>

Source: IPEDS
INTERNATIONAL STUDENT DEMAND

Based on anecdotal evidence, international interest in interdisciplinary sciences is also rising, suggesting that international markets may be strong sources for potential students and employers. DNA, an Indian newspaper, reported in 2011 that college-bound students in India were eschewing pure science fields in favor of applied sciences such as mechanical engineering, computer science, electronics, and communication. According to the author, part of the drive to pursue applied sciences fields has stemmed from attractive and stable employment opportunities linked with these fields.16

There is evidence that international universities are also taking advantage of growing interest in interdisciplinary science, establishing academic programs at the doctoral level. For example, the Nanyang Technological University in Singapore established its Interdisciplinary Graduate School (IGS) in 2012. The program focuses on three scientific areas—sustainability, healthcare, and new media—and requires that students specialize in two different scientific disciplines. The IGS admitted 25 Ph.D. students in its first class and expected to add 75 students to that total over the course of 2012-2013. The IGS also works with universities in Austria and Germany to provide joint Ph.D. programs.17 Similarly, the Masdar Institute in Abu Dhabi recently established its Interdisciplinary Doctoral Degree Program (IDDP), which trains students in multiple scientific and technical disciplines. The IDDP is focused on applied sciences, and graduates receive a Ph.D. in Interdisciplinary Engineering.18

SECTION II: LABOR MARKET OUTLOOK

This section examines the labor market outlook for potential graduates of the proposed Interdisciplinary Applied Science and Mathematics program. We examine national, state, and local employment projections in order to estimate future growth in the market for new graduates, as well as explore regional job listings for information on specific opportunities in the area.

LABOR MARKET OUTLOOK METHODOLOGY

To determine the labor market outlook for holders of Ph.D. degrees in applied science and mathematics, we consult national employment projections published by the U.S. Bureau of Labor Statistics (BLS). The BLS provides 10-year labor market estimates for almost 1,000 different occupations classified according to Standard Occupational Classification (SOC) codes. We used crosswalk tables mapping CIP codes to SOC codes provided by the NCES to link the academic disciplines in the previous student demand section to corresponding occupations. In order to capture the vast array of potential occupations for graduates of an interdisciplinary program in Applied Science and Mathematics, we consulted the crosswalk using the broadest CIP categories possible: the two-digit categories of Engineering, Biological Sciences, Mathematics and Statistics, and Physical Sciences. This generated a list of 67 occupations. We then removed occupations relating to social sciences and focused on broader occupational categories where possible, resulting in a final list of 26 occupations of interest. Figure 2.1 below contains descriptions for each of these positions.

<table>
<thead>
<tr>
<th>SOC Code</th>
<th>Occupation</th>
<th>Job Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>11-3051</td>
<td>Industrial Production Managers</td>
<td>Plan, direct, or coordinate the work activities and resources necessary for manufacturing products in accordance with cost, quality, and quantity specifications.</td>
</tr>
<tr>
<td>11-9041</td>
<td>Architectural and Engineering Managers</td>
<td>Plan, direct, or coordinate activities in such fields as architecture and engineering or research and development in these fields.</td>
</tr>
<tr>
<td>11-9121</td>
<td>Natural Sciences Managers</td>
<td>Plan, direct, or coordinate activities in such fields as life sciences, physical sciences, mathematics, statistics, and research and development in these fields.</td>
</tr>
<tr>
<td>15-1111</td>
<td>Computer and Information Research Scientists</td>
<td>Conduct research into fundamental computer and information science as theorists, designers, or inventors.</td>
</tr>
<tr>
<td>15-2021</td>
<td>Mathematicians</td>
<td>Conduct research in fundamental mathematics or in application of mathematical techniques to science, management, and other fields. Solve problems in various fields using mathematical methods.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SOC Code</th>
<th>Occupation</th>
<th>Job Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-2031</td>
<td>Operations Research Analysts</td>
<td>Formulate and apply mathematical modeling and other optimizing methods to develop and interpret information that assists management with decision making, policy formulation, or other managerial functions. May collect and analyze data and develop decision support software, service, or products. May develop and supply optimal time, cost, or logistics networks for program evaluation, review, or implementation.</td>
</tr>
<tr>
<td>15-2041</td>
<td>Statisticians</td>
<td>Develop or apply mathematical or statistical theory and methods to collect, organize, interpret, and summarize numerical data to provide usable information. May specialize in fields such as bio-statistics, agricultural statistics, business statistics, or economic statistics. Includes mathematical and survey statisticians.</td>
</tr>
<tr>
<td>15-2091</td>
<td>Mathematical Technicians</td>
<td>Apply standardized mathematical formulas, principles, and methodology to technological problems in engineering and physical sciences in relation to specific industrial and research objectives, processes, equipment, and products.</td>
</tr>
<tr>
<td>17-2031</td>
<td>Biomedical Engineers</td>
<td>Apply knowledge of engineering, biology, and biomechanical principles to the design, development, and evaluation of biological and health systems and products, such as artificial organs, prostheses, instrumentation, medical information systems, and health management and care delivery systems.</td>
</tr>
<tr>
<td>17-2041</td>
<td>Chemical Engineers</td>
<td>Design chemical plant equipment and devise processes for manufacturing chemicals and products, such as gasoline, synthetic rubber, plastics, detergents, cement, paper, and pulp, by applying principles and technology of chemistry, physics, and engineering.</td>
</tr>
<tr>
<td>17-2051</td>
<td>Civil Engineers</td>
<td>Perform engineering duties in planning, designing, and overseeing construction and maintenance of building structures, and facilities, such as roads, railroads, airports, bridges, harbors, channels, dams, irrigation projects, pipelines, power plants, and water and sewage systems. Includes architectural, structural, traffic, ocean, and geo-technical engineers.</td>
</tr>
<tr>
<td>17-2071</td>
<td>Electrical Engineers</td>
<td>Research, design, develop, test, or supervise the manufacturing and installation of electrical equipment, components, or systems for commercial, industrial, military, or scientific use.</td>
</tr>
<tr>
<td>17-2081</td>
<td>Environmental Engineers</td>
<td>Research, design, plan, or perform engineering duties in the prevention, control, and remediation of environmental hazards using various engineering disciplines. Work may include waste treatment, site remediation, or pollution control technology.</td>
</tr>
<tr>
<td>17-2112</td>
<td>Industrial Engineers</td>
<td>Design, develop, test, and evaluate integrated systems for managing industrial production processes, including human work factors, quality control, inventory control, logistics and material flow, cost analysis, and production coordination.</td>
</tr>
<tr>
<td>17-2131</td>
<td>Materials Engineers</td>
<td>Evaluate materials and develop machinery and processes to manufacture materials for use in products that must meet specialized design and performance specifications. Develop new uses for known materials. Includes those engineers working with composite materials or specializing in one type of material, such as graphite, metal and metal alloys, ceramics and glass, plastics and polymers, and naturally occurring materials. Includes metallurgists and metallurgical engineers, ceramic engineers, and welding engineers.</td>
</tr>
<tr>
<td>17-2141</td>
<td>Mechanical Engineers</td>
<td>Perform engineering duties in planning and designing tools, engines, machines, and other mechanically functioning equipment. Oversee installation, operation, maintenance, and repair of equipment such as centralized heat, gas, water, and steam systems.</td>
</tr>
<tr>
<td>SOC Code</td>
<td>Occupation</td>
<td>Job Description</td>
</tr>
<tr>
<td>----------</td>
<td>------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>19-1021</td>
<td>Biochemists and Biophysicists</td>
<td>Study the chemical composition or physical principles of living cells and organisms, their electrical and mechanical energy, and related phenomena. May conduct research to further understanding of the complex chemical combinations and reactions involved in metabolism, reproduction, growth, and heredity. May determine the effects of foods, drugs, serums, hormones, and other substances on tissues and vital processes of living organisms.</td>
</tr>
<tr>
<td>19-1022</td>
<td>Microbiologists</td>
<td>Investigate the growth, structure, development, and other characteristics of microscopic organisms, such as bacteria, algae, or fungi. Includes medical microbiologists who study the relationship between organisms and disease or the effects of antibiotics on microorganisms.</td>
</tr>
<tr>
<td>19-2012</td>
<td>Physicists</td>
<td>Conduct research into physical phenomena, develop theories on the basis of observation and experiments, and devise methods to apply physical laws and theories.</td>
</tr>
<tr>
<td>19-2031</td>
<td>Chemists</td>
<td>Conduct qualitative and quantitative chemical analyses or experiments in laboratories for quality or process control or to develop new products or knowledge.</td>
</tr>
<tr>
<td>19-2032</td>
<td>Materials Scientists</td>
<td>Research and study the structures and chemical properties of various natural and synthetic or composite materials, including metals, alloys, rubber, ceramics, semiconductors, polymers, and glass. Determine ways to strengthen or combine materials or develop new materials with new or specific properties for use in a variety of products and applications. Includes glass scientists, ceramic scientists, metallurgical scientists, and polymer scientists.</td>
</tr>
<tr>
<td>25-1022</td>
<td>Mathematical Science Postsecondary Teachers</td>
<td>Teach courses pertaining to mathematical concepts, statistics, and actuarial science and to the application of original and standardized mathematical techniques in solving specific problems and situations. Includes both teachers primarily engaged in teaching and those who do a combination of teaching and research.</td>
</tr>
<tr>
<td>25-1032</td>
<td>Engineering Postsecondary Teachers</td>
<td>Teach courses pertaining to the application of physical laws and principles of engineering for the development of machines, materials, instruments, processes, and services. Includes teachers of subjects such as chemical, civil, electrical, industrial, mechanical, mineral, and petroleum engineering. Includes both teachers primarily engaged in teaching and those who do a combination of teaching and research.</td>
</tr>
<tr>
<td>25-1042</td>
<td>Biological Science Postsecondary Teachers</td>
<td>Teach courses in biological sciences. Includes both teachers primarily engaged in teaching and those who do a combination of teaching and research.</td>
</tr>
<tr>
<td>25-1052</td>
<td>Chemistry Postsecondary Teachers</td>
<td>Teach courses pertaining to the chemical and physical properties and compositional changes of substances. Work may include instruction in the methods of qualitative and quantitative chemical analysis. Includes both teachers primarily engaged in teaching, and those who do a combination of teaching and research.</td>
</tr>
<tr>
<td>25-1054</td>
<td>Physics Postsecondary Teachers</td>
<td>Teach courses pertaining to the laws of matter and energy. Includes both teachers primarily engaged in teaching and those who do a combination of teaching and research.</td>
</tr>
</tbody>
</table>

Source: BLS

**NATIONAL LABOR MARKET OUTLOOK**

BLS data project that opportunities in all 26 occupations selected for review will increase over the next decade. The fastest-growing occupation will be Biomedical Engineers (4.93
percent annually), followed by Biochemists/Biophysicists (2.74 percent annually), Environmental Engineers (2.01 percent annually), and Civil Engineers (1.79 percent annually). The most opportunity in terms of sheer growth in the number of job openings is expected to be seen amongst Postsecondary Teachers (586,100 openings), Civil Engineers (104,400 openings), and Mechanical Engineers (99,600 openings). The figure below presents occupational projections for the 26 relevant career fields through 2020.

Figure 2.2: National Employment Projections for Applied Science and Mathematics-Related Careers, 2010-2020

<table>
<thead>
<tr>
<th>SOC Code</th>
<th>Occupation</th>
<th>Total Employment*</th>
<th>Employment Change</th>
<th>CAGR</th>
<th>Job Openings 2010-2020†</th>
</tr>
</thead>
<tbody>
<tr>
<td>11-3051</td>
<td>Industrial Production Managers</td>
<td>150,300</td>
<td>164,000</td>
<td>13,700</td>
<td>9.1%</td>
</tr>
<tr>
<td>11-9041</td>
<td>Architectural and Engineering Managers</td>
<td>176,800</td>
<td>192,000</td>
<td>15,200</td>
<td>8.6%</td>
</tr>
<tr>
<td>11-9121</td>
<td>Natural Sciences Managers</td>
<td>49,300</td>
<td>53,100</td>
<td>3,800</td>
<td>7.7%</td>
</tr>
<tr>
<td>15-1111</td>
<td>Computer and Information Research Scientists</td>
<td>28,200</td>
<td>33,500</td>
<td>5,300</td>
<td>18.7%</td>
</tr>
<tr>
<td>15-2021</td>
<td>Mathematicians</td>
<td>3,100</td>
<td>3,600</td>
<td>500</td>
<td>15.7%</td>
</tr>
<tr>
<td>15-2031</td>
<td>Operations Research Analysts</td>
<td>64,600</td>
<td>74,000</td>
<td>9,400</td>
<td>14.6%</td>
</tr>
<tr>
<td>15-2041</td>
<td>Statisticians</td>
<td>25,100</td>
<td>28,600</td>
<td>3,500</td>
<td>14.1%</td>
</tr>
<tr>
<td>15-2091</td>
<td>Mathematical Technicians</td>
<td>1,100</td>
<td>1,100</td>
<td>100</td>
<td>6.2%</td>
</tr>
<tr>
<td>17-2031</td>
<td>Biomedical Engineers</td>
<td>15,700</td>
<td>25,400</td>
<td>9,700</td>
<td>61.7%</td>
</tr>
<tr>
<td>17-2051</td>
<td>Chemical Engineers</td>
<td>30,200</td>
<td>32,000</td>
<td>1,800</td>
<td>5.9%</td>
</tr>
<tr>
<td>17-2071</td>
<td>Civil Engineers</td>
<td>262,800</td>
<td>313,900</td>
<td>51,100</td>
<td>19.4%</td>
</tr>
<tr>
<td>17-2081</td>
<td>Electrical Engineers</td>
<td>154,000</td>
<td>164,700</td>
<td>10,700</td>
<td>7.0%</td>
</tr>
<tr>
<td>17-2112</td>
<td>Environmental Engineers</td>
<td>51,400</td>
<td>62,700</td>
<td>11,300</td>
<td>21.9%</td>
</tr>
<tr>
<td>17-2131</td>
<td>Industrial Engineers</td>
<td>203,900</td>
<td>217,000</td>
<td>13,100</td>
<td>6.4%</td>
</tr>
<tr>
<td>17-2141</td>
<td>Materials Engineers</td>
<td>22,300</td>
<td>24,200</td>
<td>1,900</td>
<td>8.7%</td>
</tr>
<tr>
<td>17-2141</td>
<td>Mechanical Engineers</td>
<td>243,200</td>
<td>264,600</td>
<td>21,300</td>
<td>8.8%</td>
</tr>
<tr>
<td>19-1021</td>
<td>Biochemists and Biophysicists</td>
<td>25,100</td>
<td>32,900</td>
<td>7,700</td>
<td>30.8%</td>
</tr>
<tr>
<td>19-1022</td>
<td>Microbiologists</td>
<td>20,300</td>
<td>22,900</td>
<td>2,700</td>
<td>13.3%</td>
</tr>
<tr>
<td>19-1012</td>
<td>Physicists</td>
<td>18,300</td>
<td>20,900</td>
<td>2,600</td>
<td>14.2%</td>
</tr>
<tr>
<td>19-2031</td>
<td>Chemists</td>
<td>82,200</td>
<td>85,400</td>
<td>3,200</td>
<td>3.8%</td>
</tr>
<tr>
<td>19-2032</td>
<td>Materials Scientists</td>
<td>8,700</td>
<td>9,500</td>
<td>900</td>
<td>10.2%</td>
</tr>
<tr>
<td>25-1000</td>
<td>Postsecondary Teachers</td>
<td>1,756,000</td>
<td>2,061,700</td>
<td>305,700</td>
<td>17.4%</td>
</tr>
</tbody>
</table>

* The BLS' employment projections round totals to the nearest 100.
† Due to Growth and Replacement
Source: BLS

In order to take a more concise view of the labor projections offered in the figure above, below we present **total projections based on broad occupational categories**. Note that the figure below does not present total projections for whole SOC categories, as not all occupations within each broad category are applicable to the proposed program. Instead, we present totals for the above relevant occupations. As the figure below makes evident, notable growth is projected for each group through 2020, particularly in postsecondary education and computer and mathematical occupations. These occupations are projected to see the highest compound growth as well as the greatest total change in employment. Aside from postsecondary teachers, architecture and engineering occupations are projected to see the greatest sheer number of job openings over the 10 year period. Nationally, employers are projected to require approximately 120,730 employees trained to enter the fields listed above annually through 2020. **It is clear that math, engineering, and university-level teaching will be in demand at the national level through 2020.**

**Figure 2.3: National Employment Projections for Applied Science and Mathematics-Related Careers, by Broad Occupational Category, 2010-2020**

<table>
<thead>
<tr>
<th>SOC Code</th>
<th>Occupation</th>
<th>Total Employment</th>
<th>Employment Change</th>
<th>CAGR</th>
<th>Job Openings 2010-2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>11-0000</td>
<td>Management Occupations</td>
<td>376,400</td>
<td>409,100</td>
<td>32,700</td>
<td>8.7% 0.8%</td>
</tr>
<tr>
<td>15-0000</td>
<td>Computer and Mathematical Occupations</td>
<td>122,100</td>
<td>140,800</td>
<td>18,800</td>
<td>15.3% 1.4%</td>
</tr>
<tr>
<td>17-0000</td>
<td>Architecture and Engineering Occupations</td>
<td>983,500</td>
<td>1,104,500</td>
<td>120,900</td>
<td>12.3% 1.2%</td>
</tr>
<tr>
<td>19-0000</td>
<td>Life, Physical, and Social Science Occupations</td>
<td>154,600</td>
<td>171,600</td>
<td>17,100</td>
<td>11.0% 1.0%</td>
</tr>
<tr>
<td>25-0000</td>
<td>Education, Training, and Library Occupations</td>
<td>1,756,000</td>
<td>2,061,700</td>
<td>305,700</td>
<td>17.4% 1.6%</td>
</tr>
</tbody>
</table>

Source: BLS

**ADDITIONAL NATIONAL INDICATORS**

The BLS projects strong competition for research appointments, as “the number of research proposals submitted for funding has been growing faster than the amount of funds available, causing competition for research grants.” However, “declines in basic research are expected to be offset by growth in applied research in private industry.” The BLS predicts that, in research fields, doctoral degree holders with interdisciplinary knowledge will see the most favorable job prospects. This is true for physicists, biological scientists, mathematicians, and computer and information researchers.

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The BLS predicts slightly above-average job growth for postsecondary teachers. However, the BLS does not divide postsecondary teachers into academic fields, making it impossible to determine job prospects for applied science professors, specifically.26

### OHIO PROJECTIONS

The Ohio Department of Job and Family Services (DJFS) predicts that employment opportunities will increase for all relevant occupations through 2020, particularly for Biomedical Engineers (4.3 percent annually), Biochemists and Biophysicists (2.3 percent annually), and Computer and Information Research Scientists (1.8 percent annually). The pace of growth for these occupations in Ohio, however, is less rapid than in the nation as a whole. The DJFS does not provide employment projections for Mathematicians or Mathematical Technicians.27

#### Figure 2.4: Ohio Employment Projections for Applied Science and Mathematics-Related Careers, 2010-2020

<table>
<thead>
<tr>
<th>SOC Code</th>
<th>Occupation</th>
<th>Total Employment</th>
<th>Employment Change</th>
<th>CAGR</th>
<th>Job Openings 2010-2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>11-3051</td>
<td>Industrial Production Managers</td>
<td>10,180</td>
<td>780</td>
<td>7.7%</td>
<td>0.7%</td>
</tr>
<tr>
<td>11-9041</td>
<td>Architectural and Engineering Managers</td>
<td>6,380</td>
<td>600</td>
<td>9.4%</td>
<td>0.9%</td>
</tr>
<tr>
<td>11-9121</td>
<td>Natural Sciences Managers</td>
<td>1,100</td>
<td>70</td>
<td>6.4%</td>
<td>0.6%</td>
</tr>
<tr>
<td>15-1111</td>
<td>Computer and Information Research Scientists</td>
<td>670</td>
<td>130</td>
<td>19.4%</td>
<td>1.8%</td>
</tr>
<tr>
<td>15-2021</td>
<td>Mathematicians</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>15-2031</td>
<td>Operations Research Analysts</td>
<td>2,600</td>
<td>320</td>
<td>12.3%</td>
<td>1.2%</td>
</tr>
<tr>
<td>15-2041</td>
<td>Statisticians</td>
<td>630</td>
<td>110</td>
<td>17.5%</td>
<td>1.6%</td>
</tr>
<tr>
<td>15-2091</td>
<td>Mathematical Technicians</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>17-2031</td>
<td>Biomedical Engineers</td>
<td>340</td>
<td>180</td>
<td>52.9%</td>
<td>4.3%</td>
</tr>
<tr>
<td>17-2041</td>
<td>Chemical Engineers</td>
<td>1,380</td>
<td>120</td>
<td>8.7%</td>
<td>0.8%</td>
</tr>
<tr>
<td>17-2051</td>
<td>Civil Engineers</td>
<td>6,570</td>
<td>910</td>
<td>13.9%</td>
<td>1.3%</td>
</tr>
<tr>
<td>17-2071</td>
<td>Electrical Engineers</td>
<td>5,380</td>
<td>280</td>
<td>5.2%</td>
<td>0.5%</td>
</tr>
<tr>
<td>17-2081</td>
<td>Environmental Engineers</td>
<td>1,070</td>
<td>150</td>
<td>14.0%</td>
<td>1.3%</td>
</tr>
<tr>
<td>17-2112</td>
<td>Industrial Engineers</td>
<td>10,750</td>
<td>550</td>
<td>5.1%</td>
<td>0.5%</td>
</tr>
</tbody>
</table>


At the state level we again present cumulative demand figures for the occupations in the figure above, classified by broad occupational category. Again we find that the most growth in job openings will be experienced by architecture and engineering occupations and postsecondary teaching. While relatively fewer openings will occur in computer and mathematical occupations, it is expected that the number of such positions will grow significantly in Ohio (14.4 percent from 2010-2020). Life, physical, and social science occupations will undergo the slowest rate of growth, at only 0.6 percent per year; however, the occupation’s total change is still quite positive (5.7 percent).

Figure 2.5: Ohio Employment Projections for Applied Science and Mathematics-Related Careers, by Broad Occupational Category, 2010-2020

Overall, employers across Ohio are projected to need approximately 366 employees with a high level of expertise in science- and math-related fields each year through 2020. A new doctoral program in applied science and mathematics would likely help to meet this need.

The DJFS also reports employment projections at the local level for an earlier period—2008 through 2018. The DJFS presents a mixed outlook for science and mathematics occupations in the Dayton area, with growth occurring overall, albeit at a slower pace
than at the state and national levels. Data for several occupations are not available at the local level. Amongst those for which projections are made, Computer and Information Research Scientists are projected to see the most growth (1.3 percent annually), followed by Civil Engineers (1.1 percent annually). Despite an overall negative rate of growth, Mechanical Engineers will see the highest number of job openings each year (34), followed by Industrial Production Managers (27), again despite overall shrinkage of the workforce. This indicates that there will be high turnover and retirement amongst current employees.

Figure 2.6: Dayton Metropolitan Statistical Area, Occupational Employment Projections, 2008-2018

<table>
<thead>
<tr>
<th>SOC Code</th>
<th>Occupation</th>
<th>Total Employment</th>
<th>Employment Change</th>
<th>CAGR</th>
<th>Average Annual Openings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2008</td>
<td>2018</td>
<td>Number</td>
<td>%</td>
</tr>
<tr>
<td>11-3051</td>
<td>Industrial Production Managers</td>
<td>770</td>
<td>620</td>
<td>-150</td>
<td>-19.5%</td>
</tr>
<tr>
<td>11-9041</td>
<td>Architectural and Engineering Managers</td>
<td>660</td>
<td>600</td>
<td>-60</td>
<td>-9.1%</td>
</tr>
<tr>
<td>11-9121</td>
<td>Natural Sciences Managers</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>15-1111</td>
<td>Computer and Information Research Scientists</td>
<td>140</td>
<td>160</td>
<td>20</td>
<td>14.3%</td>
</tr>
<tr>
<td>15-2021</td>
<td>Mathematicians</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>15-2031</td>
<td>Operations Research Analysts</td>
<td>130</td>
<td>130</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>15-2041</td>
<td>Statisticians</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>15-2091</td>
<td>Mathematical Technicians</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>17-2031</td>
<td>Biomedical Engineers</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>17-2041</td>
<td>Chemical Engineers</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>17-2051</td>
<td>Civil Engineers</td>
<td>830</td>
<td>930</td>
<td>100</td>
<td>12.0%</td>
</tr>
<tr>
<td>17-2071</td>
<td>Electrical Engineers</td>
<td>440</td>
<td>410</td>
<td>-30</td>
<td>-6.8%</td>
</tr>
<tr>
<td>17-2081</td>
<td>Environmental Engineers</td>
<td>130</td>
<td>140</td>
<td>10</td>
<td>7.7%</td>
</tr>
<tr>
<td>17-2112</td>
<td>Industrial Engineers</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>17-2131</td>
<td>Materials Engineers</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SOC CODE</th>
<th>OCCUPATION</th>
<th>TOTAL EMPLOYMENT</th>
<th>EMPLOYMENT CHANGE</th>
<th>CAGR</th>
<th>AVERAGE ANNUAL OPENINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>17-2141</td>
<td>Mechanical Engineers</td>
<td>1,330</td>
<td>-90 (-6.8%)</td>
<td>-0.7%</td>
<td>34</td>
</tr>
<tr>
<td>19-1021</td>
<td>Biochemists and Biophysicists</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>19-1022</td>
<td>Microbiologists</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>19-2012</td>
<td>Physicists</td>
<td>120</td>
<td>10 (8.3%)</td>
<td>0.8%</td>
<td>4</td>
</tr>
<tr>
<td>19-2031</td>
<td>Chemists</td>
<td>230</td>
<td>0 (0%)</td>
<td>0%</td>
<td>8</td>
</tr>
<tr>
<td>19-2032</td>
<td>Materials Scientists</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>25-1000</td>
<td>Postsecondary Teachers</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: Ohio Department of Job and Family Services

**REGIONAL EMPLOYERS**

A number of companies in Ohio—particularly in the Dayton area—are actively seeking Ph.D. degree holders to perform research and develop new technologies. Two major local employers—the Air Force Research Laboratory and the Air Force Institute of Technology—regularly hire new researchers, and dozens of other companies in the region seek applicants with applied science backgrounds. In the pages to follow, we provide brief overviews of the Air Force Research Laboratory and the Air Force Institute of Technology and present a sample of other companies with relevant job postings in Ohio.

**AIR FORCE RESEARCH LABORATORY**

The Air Force Research Laboratory (AFRL), headquartered at Wright-Patterson Air Force Base (WPAFB) near Dayton, Ohio, employs professionals in science, engineering, and technology. The only currently available positions shown on the U.S. government’s USAJOBS website are for Professional Engineers. However, the AFRL has been granted Direct Hire Authority, which allows it to hire qualified applicants outside of the standard government hiring process. The AFRL invites holders of advanced degrees in a variety of mathematics and science fields to apply directly to the AFRL for employment consideration.


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29 “Search Results for ‘AFRL’” USAJOBS. [https://www.usajobs.gov/JobSearch/Search/GetResults?Keyword=%22AFRL%22&Location=&search.x=43&search.y=19&search=Search%21&AutoCompleteSelected=0](https://www.usajobs.gov/JobSearch/Search/GetResults?Keyword=%22AFRL%22&Location=&search.x=43&search.y=19&search=Search%21&AutoCompleteSelected=0)

While the Nanomaterial Ph.D. Research position is the only job opportunity that requires a Ph.D., the other job titles illustrate some of the research fields being explored at AFRL.

**AIR FORCE INSTITUTE OF TECHNOLOGY**

Graduates from the proposed Interdisciplinary Applied Science and Mathematics program may also find employment at the Air Force Institute of Technology (AFIT), located at WPAFB. Current job openings at the AFIT include the position of Director of Institutional Research, a position advertised to experienced researchers with doctorate degrees in quantitative disciplines.

**OTHER OHIO EMPLOYERS**

A simple job search for employment opportunities in Ohio reveals that a number of area employers seek applicants with Ph.D. degrees in applied science fields. Figure 2.7 lists a number of other local and regional employers, relevant job openings, and the education requirements for those positions.

**Figure 2.7: Current Ohio Job Openings for Holders of Applied Science Ph.D. Degrees**

<table>
<thead>
<tr>
<th>COMPANY</th>
<th>LOCATION</th>
<th>JOB</th>
<th>REQUIREMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTAS(^{35})</td>
<td>WPAFB</td>
<td>Research and Development</td>
<td>Master’s or Ph.D. in scientific field</td>
</tr>
<tr>
<td>Riverside Research(^{36})</td>
<td>Dayton</td>
<td>Test and Evaluation Subject Matter Expert</td>
<td>Ph.D. in technical field such as statistics, operations research, or related discipline preferred</td>
</tr>
<tr>
<td>Wyle(^{37})</td>
<td>Dayton</td>
<td>Electronic/Photonic Device Research Engineer</td>
<td>Ph.D. in electrical engineering, materials engineering, mechanical engineering, physics, optics, or related field</td>
</tr>
</tbody>
</table>

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32 “Nanomaterial Ph.D. Research.” Oak Ridge Institute for Science and Education. https://www.pcrecruiter.net/prcbin/reg5.exe?db=GpQiuHPfuYugLKOgMcuiJ2YRUg7qMNIfugqlwOz8P8dmVKI1o%3d&sid=162056400157785&src=indeed&rid=www%2Eindeed%2Ecom
33 “About AFIT.” Air Force Institute of Technology. http://www.afit.edu/about.cfm
34 “Director of Institutional Research, AD-1701-25.” USAJOBS. https://www.usajobs.gov/GetJob/ViewDetails/339781200
37 “AERO-OH-DA-12-101: Electronic/Photonic Device Research Engineer.” Wyle. http://careers.wyle.com/Careers.aspx?data=OxOh8%2bZoVixBCv5z5RQ38if5CPGJs2M1u4GmntKHTuyg5Dk8gLef9wlq5EoQUBrsieDYZCoaOfHSFuXfnvTQezhCU1KdIt3OxsR0u0%3d
<table>
<thead>
<tr>
<th>COMPANY</th>
<th>LOCATION</th>
<th>JOB</th>
<th>REQUIREMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAIS</td>
<td>Beavercreek</td>
<td>Chief Scientist, Spectrum Warfare</td>
<td>Ph.D. in related fields such as electrical engineering, physics, optics, or computer engineering</td>
</tr>
<tr>
<td>General Electric</td>
<td>Cincinnati</td>
<td>Solid State Physicist</td>
<td>Master’s in physics or related discipline; Ph.D. in solid state physics preferred</td>
</tr>
<tr>
<td>Procter &amp; Gamble</td>
<td>Cincinnati</td>
<td>Post Doctoral Scientist</td>
<td>Ph.D. in proteomics, biochemistry, bioanalytical chemistry, cell biology, or a closely related field</td>
</tr>
<tr>
<td>Lubrizol</td>
<td>Brecksville</td>
<td>Senior Research Scientist</td>
<td>Ph.D. in physical chemistry, chemical engineering, materials science, or physics</td>
</tr>
</tbody>
</table>

Source: Indeed.com, company websites

The figure above represents only a small portion of the employment opportunity in Ohio for graduates of a doctoral program in applied science and mathematics. The American Council of Engineering Companies of Ohio lists approximately 231 Ohio firms that provide engineering and other professional services. The companies are located across Ohio, as follows:

- Central Ohio: 65
- Northeast Ohio: 90
- Northwest Ohio: 20
- Southeast Ohio: 1
- Southwest Ohio: 55

Similarly, the University of Ohio lists 157 biotechnology, biomedical, and bioinformatics companies within the state. Any of these 388 Ohio companies may offer employment opportunities for graduates of the proposed program, to say nothing of the opportunity that awaits students who desire to leave the state.

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43 “Regional Biotech Companies.” University of Ohio. http://www.ohio.edu/engineering/biomedical/jobs/biotechlist.cfm
INTERNATIONAL RESEARCH

Graduates of applied science and mathematics Ph.D. programs may also find work outside of the United States with international research organizations. Emphasis on interdisciplinary applied science research is becoming increasingly common around the world. Because many of the world’s problems are global in nature, interaction among scientists from different countries is essential to resolving those issues efficiently. For example, the devastating earthquake in Pakistan in 2005 led to a surge in demand for new biomedical materials to rehabilitate those injured in the natural disaster. In response, the COMSATS Institute of Information Technology created the Interdisciplinary Research Centre in Biomedical Materials (IRCBM). The IRCBM seeks to establish an indigenous response to biomedical materials demand by collaborating with research institutions around the world.

The International Council for Science (ICSU), an organization of scientific bodies and International Scientific Unions representing 140 countries, is a leader in supporting collaboration between countries in the interdisciplinary sciences. It recognizes that science is increasingly global and more interconnected than ever. Organizations such as the ICSU facilitate such exchange by developing initiatives that create opportunities for scientists with varied skill sets. For example, the ICSU established the Future Earth initiative in 2012 as an international, interdisciplinary, collaborative effort to respond to global environmental change. This initiative reflects a growing need for interdisciplinary research that transcends national borders, creating further opportunities for scientists who already possess an interdisciplinary applied science background.

A similar international collaborative effort is the InterAcademy Council, which leverages international and interdisciplinary research from its members around the world to create reports that address global issues. The International Conference on Recent Trends in Applied Sciences with Engineering Applications in Bhopal, India, is another example of evident international interest in the applied and interdisciplinary sciences.

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SECTION III: FUNDING

Wright State University’s Program Development Plan (PDP) identifies a number of strategic partnerships that can provide resources to support the Interdisciplinary Applied Science and Mathematics program. The PDP also notes that program faculty members have already been successful in securing extramural funding. This section identifies additional sources of funding for a fledgling Ph.D. program.

Most grants from federal and foundation sources for STEM are aimed at K-16 education, though there are a few promising programs for graduate institutions (profiled below). On the federal side, there are many grants for scholarships and postdoctoral research fellowships through various government agencies (typically NSF), though it is rare to find a grant program earmarked for university Ph.D. programs in STEM fields. For the private foundations listed below, all accept unsolicited applications and have a recent history of giving within Ohio.

<table>
<thead>
<tr>
<th>PROGRAM/GRANTMAKER</th>
<th>RECOMMENDED REQUEST RANGE</th>
<th>INITIAL APPROACH</th>
<th>DEADLINE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FOUNDATION FUNDING</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alfred P. Sloan Foundation</td>
<td>$100,000-$500,000</td>
<td>Online application</td>
<td>Rolling</td>
</tr>
<tr>
<td>Battelle Memorial Institute</td>
<td>$50,000-$200,000</td>
<td>TBA</td>
<td>TBA 2014</td>
</tr>
<tr>
<td>JPMorgan Chase Foundation</td>
<td>$25,000-$75,000</td>
<td>Online LOI</td>
<td>Rolling</td>
</tr>
<tr>
<td><strong>FEDERAL FUNDING</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSF—STC</td>
<td>$25 million-$40 million</td>
<td>Online application</td>
<td>TBA 2014</td>
</tr>
<tr>
<td>NSF—IGERT</td>
<td>$500,000-$3 million</td>
<td>Online application</td>
<td>TBA 2014</td>
</tr>
<tr>
<td>NSF—AGEP</td>
<td>Varies</td>
<td>Online application</td>
<td>Varies</td>
</tr>
<tr>
<td>NSF—MRSEC</td>
<td>$2.5 million-$4 million</td>
<td>Online application</td>
<td>August 26, 2013</td>
</tr>
<tr>
<td>DoD/ONR—STEM</td>
<td>$25,000-$200,000</td>
<td>Online application</td>
<td>September 30, 2013</td>
</tr>
<tr>
<td>DoD/AF—MURI</td>
<td>$1.5 million per year (up to three years)</td>
<td>Online application</td>
<td>TBA 2014</td>
</tr>
<tr>
<td>DoE—LEDP</td>
<td>Varies (equipment)</td>
<td>E-mail</td>
<td>Rolling</td>
</tr>
<tr>
<td>DoD—NDSEG</td>
<td>Varies (scholarship)</td>
<td>Online application</td>
<td>January 2014</td>
</tr>
<tr>
<td>NSF—BBBE</td>
<td>$100,000-$200,000 (scholarship)</td>
<td>Online application</td>
<td>August 15 to September 17, 2013</td>
</tr>
</tbody>
</table>
FOUNDATION FUNDING

A previous funder of WSU, the Battelle Memorial Institute donates roughly $10 million each year to charitable causes, with the vast majority supporting education initiatives aligned to its four integrated STEM learning priorities. The Institute concentrates its efforts on developing and spreading innovative STEM education practices. Funding for education programming aligned Battelle’s strategic education objectives is made available periodically through its STEM Grant Program. The program is currently closed for FY2013, but details for FY2014 funding should be posted soon.

The Alfred P. Sloan Foundation gave over $44 million in grants to educational institutions in FY2011. The Foundation makes grants to support original research and broad-based education related to science, technology, and economic performance. In each grant program, the Foundation seeks proposals for original projects led by outstanding individuals or teams; the Foundation has long supported students interested in STEM careers. The Foundation additionally provides fellowship funds to encourage underrepresented minorities to pursue STEM careers. The Foundation accepts applications at any time; major program areas are listed here.

The JPMorgan Chase Foundation’s three main areas of interest are community development, education, and arts and culture. The Foundation strives to achieve its education priority area goals through supporting staff development, implementation of innovative curricula, deepening teacher content knowledge, strengthening of instructional strategies, strengthening capacity to support innovation, extending learning opportunities, and dissemination of best practices. To this end, the Foundation has given over $26 million to educational institutions within Ohio in the past decade, including many STEM grants to universities. To be considered for support, applicants must submit a letter of inquiry online, which is accepted at any time.

GOVERNMENT FUNDING

NATIONAL SCIENCE FOUNDATION

NSF’s Office of International and Integrative Activities’ Science and Technology Centers: Integrative Partnerships program supports innovative, potentially transformative, complex research and education projects that require large-scale, long-term awards. STCs conduct world-class research through partnerships among academic institutions, national laboratories, industrial organizations, and/or other public/private entities, and via international collaborations, as appropriate. They provide a means to undertake significant investigations at the interfaces of disciplines and/or fresh approaches within disciplines. STCs may involve any areas of science and engineering that NSF supports. STC investments support the NSF vision of advancing discovery, innovation, and education beyond the frontiers of current knowledge, and empowering future generations in science and engineering. A list of past awards is provided here; awards typically range from $25 million to $40 million. Applications are currently closed for FY2013, but should re-open next year.
Another promising source of funding for interdisciplinary research is the **NSF’s Integrative Graduate Education and Research Traineeship (IGERT)** program, which funds graduate education for students in STEM fields. Grant amounts **typically range** from $500,000 to $3 million, with the majority over $100,000. The NSF currently funds roughly **150 active IGERT** programs for fields such as mathematical biology, nanomedical science and technology, and wind energy science. A new funding cycle has yet to be announced for FY2013, and may be pushed back into FY2014.

**NSF’s Alliances for Graduate Education and the Professoriate (AGEP)** is a **program area** committed to the national goal of increasing the numbers of under-represented minorities (URMs) entering and completing graduate education and postdoctoral training to levels representative of the available pool of URMs. AGEP projects must focus on URM U.S. citizens in STEM graduate education, and/or postdoctoral training, and their preparation for academic STEM careers at all types of institutions of higher education. AGEP is interested in proposals that include any or all STEM fields supported by NSF including the social, behavioral and economic sciences, and multi-, cross-, or inter-disciplinary STEM fields. There are more than a **dozen individual programs** (with varying deadlines and funding levels) within the AGEP program area which may apply to WSU’s needs.

**NSF’s Directorate for Mathematical and Physical Sciences** currently operates a **Materials Research Science and Engineering Centers** program. MRSECs provide sustained support of interdisciplinary materials research and education of the highest quality while addressing fundamental problems in science and engineering. MRSECs address research of a scope and complexity requiring the scale, synergy, and interdisciplinarity provided by a campus-based research center. They support materials research infrastructure in the U.S., promote active collaboration between universities and other sectors, including industry and international institutions, and contribute to the development of a national network of university-based centers in materials research, education, and facilities. A MRSEC may be located at a single institution, or may involve multiple institutions in partnership. A total of $25 million in funding for FY2014 will be divided among approximately 7-10 awards. Preliminary proposals are due by **August 26, 2013**.

**OTHER FEDERAL PROGRAMS (DoD, DoE, NIH)**

DoD and the **Office of Naval Research (ONR)** have a current **funding opportunity** entitled **STEM for K-12 and Institutions of Higher Learning**. ONR is interested in receiving proposals for developing innovative solutions that directly support the development and maintenance of a robust STEM workforce. Successful efforts will be targeted towards various program areas, including graduate-level STEM education. The goal of any proposed effort should be to provide “game changing” solutions that will establish and maintain a diverse pipeline of U.S. citizens who are interested in participating in Naval STEM education programs and who ultimately will be interested in STEM careers. Applications are due on **September 30, 2013**, with projected grant awards of $25,000 to $200,000.
DoD and the U.S. Air Force have an interesting program entitled the Multidisciplinary Research Program of the University Research Initiative (MURI). MURI supports basic research in the science and engineering areas intersecting more than one traditional discipline. The program is focused on multidisciplinary team efforts to address issues of critical concern to the DoD and the AF. The goal of this program is to advance defense research, accelerate technology transition, and educate scientists and engineers in the interdisciplinary areas important to national defense. Awards are typically for a period of three years with two additional years as options; new awards can be funded up to $1.5 million per year. Proposal submission is a two-stage process including white papers and full proposals. Applications are currently closed, but this program has typically been renewed every two years, meaning that a new funding cycle should begin in FY2014.

The Department of Energy has a slightly unusual but perhaps helpful Laboratory Equipment Donation Program. In accordance with its responsibility to encourage research and development in the energy area, DoE awards grants of used energy-related laboratory equipment. Participation in the LEDP is limited to institutes of higher education as well as certain non-profit organizations which are located in the U.S. and interested in establishing or upgrading energy-oriented educational programs in the life, physical, and environmental sciences and in engineering. WSU is eligible to apply; applications are accepted at any time.

**Scholarships and Fellowship Support**

In terms of scholarship support, DoD’s National Defense Science and Engineering Graduate Fellowship Program looks promising for future students of the proposed interdisciplinary program at WSU. The NDSEG is a joint program of the U.S. Army, Navy, and Air Force within the University Research Initiative designed to increase the number of U.S. citizens trained in disciplines of science and engineering important to defense goals. DoD awards approximately 100-150 new three-year graduate fellowships each year to individuals for study and research leading to doctoral degrees in, or closely related to various fields that will be covered by WSU’s proposed program. Fellows are eligible to participate in research at Navy laboratories during the summer. Awards are typically made for three years, and applications are due in January of each year.

Another possible candidate for scholarship and research support is NSF’s Biotechnology, Biochemical, and Biomass Engineering program, which supports fundamental engineering research that advances the understanding of cellular and biomolecular processes and eventually leads to the development of enabling technology and/or applications in support of the biopharmaceutical, biotechnology, and bioenergy industries, or with applications in health or the environment. The duration of unsolicited awards is generally one to three years; the average annual award size for the program is $100,000 for individual investigators and $200,000 for multiple investigators. Proposals in the areas of nanobiotechnology, fermentation, cell culture, recombinant DNA, and enzyme technology will still be accepted, given that they represent highly innovative and potentially transformative research in these areas. Applications will be accepted from August 15 to September 17, 2013.
SECTION IV: PROFILES OF APPLIED SCIENCE AND MATHEMATICS PROGRAMS AT OTHER INSTITUTIONS

Our research indicates that there are few, if any, existing doctoral programs in applied science and mathematics identical to Wright State University’s proposed program. The most similar programs are in applied science, applied mathematics, computational science, or some combination of the three fields. Generally, these programs provide students with a solid foundation in applied mathematics and scientific research before allowing students to choose a specific scientific focus (e.g., Mathematical Biology, Imaging Science, or Materials Science). Such programs tend to be more specialized than the program proposed by Wright State University and do not require students to take courses in multiple scientific fields. This section profiles six programs of this kind.

METHODOLOGY

We selected the six programs in this section according to perceived similarity to the program proposed by Wright State University. The key factors considered in selection were:

- **Interdisciplinarity:** to what extent students are encouraged to study multiple disciplines, either in mathematics and science or in multiple sciences.
- **Applied mathematics:** whether or not each program requires students to take courses in applied mathematics
- **Applied sciences:** to what extent each program emphasizes applied sciences over basic or pure sciences

The programs included in this section, displayed in Figure 4.1, each exhibit some element of each of the three criteria described above.

![Figure 4.1: Applied Science and Mathematics-Related Ph.D. Programs](http://www.amcs.upenn.edu/AMCS/AMCScoursesofstudy.html)
Once we identified relevant institutions, our course of research focused on answering the following questions:

- Does the program value one discipline more than others?
- What coursework do students have to complete in order to earn a degree?
- What are the admissions requirements for the program?
- How is the program funded?
- Has the program been able to maintain a critical mass of students?

All of these questions, however, could not be answered for every program profiled. Information on funding and student enrollment was unavailable for most programs.

**The University of Maryland**

The Applied Mathematics and Statistics, and Scientific Computation (AMSC) program at the University of Maryland (UMD) allows students to pursue a doctorate degree in Applied Mathematics, Applied Statistics, or Scientific Computation. Faculty members focus their research on areas as diverse as space robotics, population dynamics and extinction risk, traffic modeling in communication networks, biomedical engineering, and microcombustion.

The AMSC program has maintained a consistent level of student participation over the past five years, averaging 88 students per year. Figure 4.2 shows the total enrollment for the program from 2008 to 2012.

**Figure 4.2: University of Maryland, Doctoral Enrollment in Applied Mathematics and Scientific Computation**

<table>
<thead>
<tr>
<th>Year</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enrollment</td>
<td>84</td>
<td>88</td>
<td>88</td>
<td>89</td>
<td>89</td>
</tr>
</tbody>
</table>

Source: The University of Maryland

---

53 “AMSC Faculty Research Interests.” The University of Maryland. http://www.amsc.umd.edu/directory/faculty_research_interests.html
54 “Student Enrollment for Fall 2008.” The University of Maryland. p. 120. https://www.irpa.umd.edu/Enroll/ebm-200808.pdf

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COURSEWORK

All of the AMSC doctorate programs require that students take at least 36 course credits and 12 credits of dissertation research. Students also must demonstrate competency through an oral examination and completion of a research dissertation.59

The Applied Mathematics doctorate degree requires that at least 18 of the 36 course credits be in primarily mathematical courses. At least nine of those 18 credits must be at the 600-898 level, and three credits must in numerical analysis. In addition, students must complete courses in their chosen area of application – either six credits at the 600-800 level or nine credits overall with three at the 600-800 level. Students must take two approved seminar courses.60 Ph.D. students in Applied Mathematics must complete three qualifying exams, including at least one in a mathematics area and at least one in their chosen application area.61

Applied Statistics students must complete four core statistics courses (Mathematical Statistics I & II and Linear Statistical Models I & II), one year of coursework in an application area, three credits of elective coursework, and three qualifying exams to obtain the Applied Statistics doctorate. The application area coursework must include at least six credits at the 600-800 level or nine credits overall with three at the 600-800 level.62

The Scientific Computation doctorate path requires students to take five core courses: Scientific Computing I & II, Computer Organization and Programming for Scientific Computing, and Advanced Scientific Computing I & II.63 In addition, students must take a set of core scientific courses64 and application courses associated with their chosen scientific areas of concentration.65 Students may choose elective courses to satisfy any remaining coursework requirements. Scientific Computation students are not required to take a qualifying examination.66

Figure 4.3 displays the courses listed within the AMSC department.67 However, students may take courses from almost any discipline they choose, including: Mathematics, Biology, Computer Science, Economics, Engineering, and Physics.68

64 “Core Science Courses.” The University of Maryland. http://www.amsc.umd.edu/programs/sc_science.html
**Figure 4.3: AMSC Courses at the University of Maryland**

<table>
<thead>
<tr>
<th>Applied Mathematics and Statistics, and Scientific Computation Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>400 Level</strong></td>
</tr>
<tr>
<td>Mathematical Modeling</td>
</tr>
<tr>
<td>Introduction to Dynamics and Chaos</td>
</tr>
<tr>
<td>Computational Methods</td>
</tr>
<tr>
<td><strong>600 Level</strong></td>
</tr>
<tr>
<td>Advanced Linear Numerical Analysis</td>
</tr>
<tr>
<td>Advanced Numerical Optimization</td>
</tr>
<tr>
<td>Numerical Methods in Partial Differential Equations</td>
</tr>
<tr>
<td>Mathematics of the Finite Element Method</td>
</tr>
<tr>
<td>Scientific Computing I &amp; II*</td>
</tr>
<tr>
<td>Advanced Topics in Applied Mathematics</td>
</tr>
<tr>
<td><strong>700 Level</strong></td>
</tr>
<tr>
<td>Applied Statistics Practicum</td>
</tr>
<tr>
<td>Applied Statistics Seminar</td>
</tr>
<tr>
<td><strong>800 Level</strong></td>
</tr>
<tr>
<td>Pre-Candidacy Research</td>
</tr>
</tbody>
</table>

* Core courses for the Scientific Computing Ph.D.  
Source: The University of Maryland

**Admissions**

The AMSC program admits 10 to 15 students every year. Applicants should possess an undergraduate degree in a field with a strong mathematics emphasis. Their academic record should also reflect a B average or higher. The AMSC program does not have set prerequisite coursework for admission to the program, although it recommends that students take:

- Linear Algebra
- Advanced Calculus
- Numerical Methods
- Differential Equations
- Probability[^69]

**Funding**

Academic departments and university institutes at UMD support the AMSC program by providing faculty members, administrative assistance, and financial support.[^70] The Department of Mathematics, Center for Scientific Computation and Mathematical Modeling, and Institute for Physical Science and Technology all provide core support for the AMSC program. Other departments and institutes participating in the program include:

- Department of Aerospace Engineering
- Department of Electrical Engineering

Individual graduate students receive funding from grants provided by organizations such as the National Science Foundation, National Physical Science Foundation, Department of Energy, Department of Homeland Security, and the National Aeronautics and Space Administration (NASA). NASA funds a specific fellowship for UMD students who study computational earth science.\(^{72}\)

The AMSC program’s collaborative research partners include:

- NASA Goddard Space Flight Center
- National Institutes of Health
- National Institute of Standards and Technology
- Naval Research Laboratory
- National Oceanic and Atmospheric Administration\(^{73}\)

**THE COLLEGE OF WILLIAM AND MARY**

The graduate program in Applied Science at the College of William and Mary is interdisciplinary by nature and relies on collaboration with the Physics, Chemistry, Biology, Computer Science, Psychology, and Mathematics departments. The research interests of the Applied Science program’s core faculty illustrate a broad range of expertise:

- Nondestructive evaluation
- Robotics and medical imaging
- Epidemic modeling and non-linear dynamics
- Nanotechnology and thin films
- Surface Science
- Laser spectroscopy
- Physical and chemical properties and characterization of polymers
- Solid state nuclear magnetic resonance
- Neurophysiology
- Electronic and magnetic materials science
- Computational neuroscience and cell biology\(^{74}\)

Approximately 50 graduate students (M.S. or Ph.D.) are currently pursuing degrees through the William and Mary Applied Science department.\(^{75}\)

**COURSEWORK**

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\(^{71}\) “Affiliates.” The University of Maryland. http://www.amsc.umd.edu/about/affiliates.html

\(^{72}\) “Funding.” The University of Maryland. http://www.amsc.umd.edu/student_info/funding.html

\(^{73}\) “AMSC Program Overview.” The University of Maryland. http://www.amsc.umd.edu/

\(^{74}\) “About Us.” The College of William and Mary. http://www.wm.edu/as/appliedscience/about/index.php

\(^{75}\) Ibid.
Ph.D. students develop an approved coursework plan with the guidance of an advisory committee, allowing them to select courses matching their chosen area of concentration (options displayed in Figure 4.4).76 The Applied Science program only requires four core courses, and those courses are not mandatory for every student. Figure 4.5 displays some of the courses available in the Applied Science graduate program.

**Figure 4.4: William and Mary Applied Science Program Concentrations**

<table>
<thead>
<tr>
<th>CONCENTRATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accelerator Science</td>
</tr>
<tr>
<td>Applied Mathematics</td>
</tr>
<tr>
<td>Applied Mechanics</td>
</tr>
<tr>
<td>Applied Robotics</td>
</tr>
<tr>
<td>Atmospheric and Environmental Science</td>
</tr>
<tr>
<td>Computational Neuroscience</td>
</tr>
<tr>
<td>Interface, Thin Film, and Surface Science</td>
</tr>
<tr>
<td>Lasers and Optics</td>
</tr>
<tr>
<td>Magnetic Resonance</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Materials Science &amp; Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematical and Computational Biology</td>
</tr>
<tr>
<td>Medical Imaging</td>
</tr>
<tr>
<td>Nanotechnology</td>
</tr>
<tr>
<td>Neuroscience</td>
</tr>
<tr>
<td>Non-Destructive Evaluation</td>
</tr>
<tr>
<td>Polymer Chemistry</td>
</tr>
<tr>
<td>Remote Sensing</td>
</tr>
</tbody>
</table>

Source: The College of William and Mary

**Figure 4.5: Applied Science Courses at The College of William and Mary**

<table>
<thead>
<tr>
<th>CORE COURSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction to Scientific Research I &amp; II</td>
</tr>
<tr>
<td>Mathematic and Computational Methods I &amp; II</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OTHER APPLIED SCIENCE COURSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied Solid State Science</td>
</tr>
<tr>
<td>Quantitative Materials Characterization</td>
</tr>
<tr>
<td>Device Processing</td>
</tr>
<tr>
<td>Lasers in Medicine, Science, and Technology</td>
</tr>
<tr>
<td>Applied Cellular Neuroscience</td>
</tr>
<tr>
<td>Applied Systems Neuroscience</td>
</tr>
<tr>
<td>Introduction to Optoelectronics</td>
</tr>
<tr>
<td>Correlated Electron Systems</td>
</tr>
<tr>
<td>Cellular Biophysics and Modeling</td>
</tr>
<tr>
<td>Self-organization in Life and Chemical Sciences</td>
</tr>
<tr>
<td>Nonlinear Dynamics</td>
</tr>
<tr>
<td>High Performance Composites</td>
</tr>
<tr>
<td>Tensor Interaction in Magnetic Resonance</td>
</tr>
<tr>
<td>Acoustic Wave Propagation in Solids</td>
</tr>
</tbody>
</table>

| Cellular Signaling in MATLAB                        |
| Bioinformatics and Molecular Evolution               |
| Solid State Nuclear Magnetic Resonance               |
| Applied Quantum Mechanics                            |
| Fundamentals of Data Acquisition and Signal Processing |
| Metallic Materials Characterization                  |
| Quantitative Nondestructive Evaluation I & II        |
| Solid Surfaces and Interfaces                        |
| Thin Film Deposition and Nanostructure Synthesis     |
| Mathematical Physiology I & II                       |
| Measurement of Material Properties                   |
| Imaging Methods                                      |
| Acoustic and EM Scattering                           |

| Polymer III - Special Topics in Polymer Chemistry    |

Source: The College of William and Mary

Students must pass a comprehensive examination to demonstrate competence in their chosen academic field. In addition, Ph.D. candidates must complete an original research project and defend it in an oral examination. William and Mary gives Ph.D. students seven years after their qualifying examination to complete the remaining degree requirements.77

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**ADMISSIONS**

William and Mary does not require that applicants possess an undergraduate degree in a specific concentration; however, most incoming students hold an undergraduate degree in natural science, mathematics, or engineering. Applicants to the William and Mary Applied Science program must submit scores from the general Graduate Record Examination (GRE) and one subject-specific GRE test. William and Mary recommends that potential students research the program’s faculty and contact the faculty member with whom they are most interested in working.\(^{78}\)

**FUNDING**

The William and Mary Applied Science program relies on both private and public funds. Private funds, which come from alumni, family and friends, and grant-funding partners, have accounted for a growing share of the program’s funding in recent years. State appropriations represented just 17.3 percent of contributions in the 2003-2004 fiscal year.

**THE UNIVERSITY OF PENNSYLVANIA**

Students may pursue a Ph.D. in Applied Mathematics and Computational Science (AMCS) at the University of Pennsylvania. Students progress from introductory applied mathematics courses to more advanced mathematics topics and courses from the applied sciences. The ultimate goal of the program is to produce professional researchers and teachers who are experts in a specific scientific concentration.\(^{79}\) Faculty members in the AMCS program come from a variety of university departments, including:

- Engineering
- Statistics
- Mathematics
- Computer Science
- Radiology
- Biology
- Geology
- Physics
- Infectious Diseases
- Risk Management\(^{80}\)

**COURSEWORK**

The program requirements for the AMCS program are the most extensive of any program reviewed in this report.

- Ph.D. students must complete 20 units of graduate courses, eight of which must be taken in residence at the University of Pennsylvania. Other credits may be transferred from approved graduate programs at other institutions.

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- Students must also make at least one presentation in conjunction with a lecture course that is mandatory for all first-year students.
- Students must pass the Masters Preliminary Exam within their first year in the AMCS program.
- Students enter Ph.D. candidacy only after passing an oral exam, which resembles “a hybrid between the subject-oriented oral exam administered by the Mathematics department and the thesis proposal used in many fields of science and engineering.”
- Students must satisfy a “real world” praxis requirement, which entails a “substantive experience” conducting laboratory research on a problem directly related to their field of specialization.
- Students must serve as a teaching assistant or instructor for at least two semesters.
- Students complete their Ph.D. degree by submitting a dissertation and defending it in a dissertation exam.\(^{81}\)

Students choose their course schedule in conjunction with the Graduate Group Chair,\(^{82}\) but all students in the AMCS program must take at least two semesters of advanced graduate courses in applied algebra and applied analysis, and at least one semester of probability and stochastic processes, as well as computational science. Students who do not pass the Masters Preliminary Exam upon arrival also take a “Proseminar,” which covers mathematics topics that support the transition from undergraduate to graduate mathematics.\(^{83}\)

Figures 4.6 and 4.7 on the following page display example coursework options for concentrations in two areas—Genomics and Bioinformatics and Imaging Science.\(^{84}\)

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**Figure 4.6: Example Coursework for a Ph.D. in Applied Mathematics and Computational Science with a Concentration in Genomics and Bioinformatics**

<table>
<thead>
<tr>
<th><strong>GENOMICS AND BIOINFORMATICS COURSEWORK</strong></th>
<th><strong>GENOMICS AND BIOINFORMATICS COURSEWORK</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied Analysis</td>
<td>Introduction to Genome Science</td>
</tr>
<tr>
<td>Advanced Computational Biology</td>
<td>Artificial Intelligence and Machine Learning</td>
</tr>
<tr>
<td>Applied Algebra</td>
<td>Mathematical Ecology</td>
</tr>
<tr>
<td>Applied Bayesian Analysis</td>
<td>Mathematical Statistics</td>
</tr>
<tr>
<td>Bayesian Statistical Theory and Methods</td>
<td>Nonlinear Control Theory</td>
</tr>
<tr>
<td>Biological Physics</td>
<td>Ordinary Differential Equations</td>
</tr>
</tbody>
</table>

---


<table>
<thead>
<tr>
<th>Computational Biology</th>
<th>Probability and Stochastic Processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evolution of Populations</td>
<td>Protein Folding</td>
</tr>
<tr>
<td>Forecasting and Time Series Analysis</td>
<td>Statistical Mechanics</td>
</tr>
<tr>
<td>Genetic Analysis</td>
<td>Statistical Methods and Computation</td>
</tr>
<tr>
<td>Genomics</td>
<td>Statistical Methods for Data Analysis I &amp; II</td>
</tr>
<tr>
<td>Introduction to Bioinformatics</td>
<td>Stochastic Processes I &amp; II</td>
</tr>
<tr>
<td>Introduction to Linear Models and Generalized Linear Models</td>
<td>Neural Networks, Chaos, and Dynamics: Theory and Application</td>
</tr>
</tbody>
</table>

Source: The University of Pennsylvania

**Figure 4.7: Example Coursework for a Ph.D. in Applied Mathematics and Computational Science with a Concentration in Imaging Science**

<table>
<thead>
<tr>
<th>IMAGING SCIENCE COURSEWORK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algebraic Techniques for Applied Mathematics and Computational Science</td>
</tr>
<tr>
<td>Introduction to Optimization Theory</td>
</tr>
<tr>
<td>Algebraic Topology</td>
</tr>
<tr>
<td>Alternative Courses</td>
</tr>
<tr>
<td>Analytic Techniques for Applied Mathematics and Computational Science</td>
</tr>
<tr>
<td>Applied Linear Analysis</td>
</tr>
<tr>
<td>Artificial Intelligence and Machine Learning</td>
</tr>
<tr>
<td>Curves and Surfaces: Theory and Applications</td>
</tr>
<tr>
<td>Digital Signal Processing</td>
</tr>
<tr>
<td>Foundations of Engineering Mathematics</td>
</tr>
<tr>
<td>Geometry-Topology, Differential Geometry I &amp; II</td>
</tr>
<tr>
<td>Geometry-Topology, Differential Geometry I &amp; II</td>
</tr>
<tr>
<td>Information Theory</td>
</tr>
</tbody>
</table>

Source: The University of Pennsylvania

**ADMISSIONS**

The AMCS program seeks students with an undergraduate degree in mathematics or equivalent mathematics experience. The AMCS program, however, also considers applicants that may lack advanced mathematics knowledge if they have experience in other applied science fields. Applicants must take both the General GRE and the Advanced Mathematics GRE Subject Test. The AMCS selects students based on a combination of past coursework,
grades, letters of recommendation (letters from mathematics or science professors are preferred), test scores, and supporting materials.  

**NORTHWESTERN UNIVERSITY**

The Northwestern University program in Engineering Sciences and Applied Mathematics leads to a Ph.D. degree in advanced applied mathematics. The courses offered by the department are understandably engineering-oriented, but the program “emphasizes flexibility in adapting research areas to current opportunities.” Research areas for applied mathematics students include:

- Topography Variation
- Bacterial Biofilms
- Trackable Items, Geocaching, and Human Mobility
- Language Competition
- Computational Neuroscience
- Complex Network Analysis of Gravitational Systems

Northwestern admits approximately 10 students every year, and students take an average of five years to complete the program. Northwestern has sustained enrollment in its Applied Mathematics doctoral program; in fact, the program has actually grown over the past decade (see Figure 4.8).

**Figure 4.8: Northwestern University, Doctoral Enrollments in Applied Mathematics**

<table>
<thead>
<tr>
<th>Year</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enrollment</td>
<td>29</td>
<td>30</td>
<td>35</td>
<td>32</td>
<td>32</td>
<td>37</td>
<td>36</td>
<td>37</td>
<td>41</td>
<td>40</td>
</tr>
</tbody>
</table>

Source: Northwestern University

Over the past 10 years, 68 percent of graduates who reported their eventual placement went on to postdoctoral research or additional training, 21 percent went directly into academic work, 6 percent worked in industry, and 4 percent worked in the government or non-profit sector.

**COURSEWORK**

Required coursework for the Ph.D. program varies depending on prior experience. Students with bachelor’s degrees must take at least 20 courses, while students that possess a master’s degree only need to take 18 courses. All students must take eight core courses that cover differential equations, asymptotic methods, mathematical modeling, and numerical

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86 “Prospective PhD Students.” Northwestern University. [http://www.esam.northwestern.edu/graduate/prospective-phd/index.html](http://www.esam.northwestern.edu/graduate/prospective-phd/index.html)
87 “What is Applied Mathematics?” Northwestern University. [http://www.esam.northwestern.edu/about/what-is-applied-math.html](http://www.esam.northwestern.edu/about/what-is-applied-math.html)
methods.\textsuperscript{91} Figure 4.9 presents a sample of courses available from the Engineering Sciences and Applied Mathematics department.\textsuperscript{92}

**Figure 4.9: Sample of Engineering Sciences and Applied Mathematics Courses at Northwestern University**

<table>
<thead>
<tr>
<th>AVAILABLE COURSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied Dynamical Systems</td>
</tr>
<tr>
<td>Stochastic Differential Equations</td>
</tr>
<tr>
<td>Modeling and Computation in Science and Engineering</td>
</tr>
<tr>
<td>Asymptotic and Perturbation Methods in Applied Mathematics</td>
</tr>
<tr>
<td>Wave Propagation</td>
</tr>
<tr>
<td>Models in Applied Mathematics</td>
</tr>
<tr>
<td>Numerical Methods for Random Processes</td>
</tr>
<tr>
<td>Combustion Theory</td>
</tr>
<tr>
<td>Methods of Nonlinear Analysis</td>
</tr>
<tr>
<td>Hydrodynamic Stability Theory</td>
</tr>
</tbody>
</table>

Source: Northwestern University

**ADMISSIONS**

Northwestern does not publish specific admissions requirements. The admissions team does look for courses such as advanced calculus, real analysis, partial differential equations, linear algebra, complex analysis, and numerical methods.\textsuperscript{93}

**COLUMBIA UNIVERSITY**

The Fu Foundation School of Engineering and Applied Science (SEAS) at Columbia University offers a Ph.D. in Applied Mathematics that “focuses on the mathematics originating from and applied to the various fields of physical sciences and engineering.”\textsuperscript{94} Some of the applications studied in the Columbia Applied Mathematics program include:

- Large-scale scientific computation
- Fluid dynamics
- Dynamical systems and chaos
- Condensed-matter physics
- Plasma physics
- Medical imaging
- Solid earth geophysics
- Cellular biophysics
- Machine learning
- Functional genomics\textsuperscript{95}

The Applied Mathematics program, like many similar programs, is a product of collaboration between multiple university departments and organizations, including the:

- Department of Applied Physics and Applied Mathematics
- Department of Astronomy
- Department of Chemistry
- Columbia Center for Computational Biology and Bioinformatics
- Center for Computational Learning Systems

\textsuperscript{91} Northwestern University, “Prospective PhD Students,” Op. cit.
\textsuperscript{92} “Course Listing,” Northwestern University. http://www.esam.northwestern.edu/courses/listing.html
\textsuperscript{93} Northwestern University, “Prospective PhD Students,” Op. cit.
Students must complete both a Master of Science (M.S.) and Master of Philosophy (M.Phil.) degree on their path toward the Ph.D. The M.S. degree requires 30 points of coursework in basic and applied mathematics; the M.Phil. degree requires completion of an additional 30-point academic program. Students also must pass a written qualifying examination, an oral examination, and a thesis proposal evaluation to obtain the M.Phil. degree. Ph.D. candidates must complete the M.S. and M.Phil. degrees and submit and defend an approved dissertation. The Ph.D. in Applied Mathematics requires completion of 10 core courses, more than any other program profiled in this report. Figure 4.10 displays the core courses and 14 other courses that students may take on their path to specialization.

**Figure 4.10: Applied Mathematics Courses at Columbia University**

<table>
<thead>
<tr>
<th>Core Courses</th>
<th>Related Courses of Specialization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principles of Applied Mathematics</td>
<td>Introduction to Numerical Methods</td>
</tr>
<tr>
<td>Dynamical Systems</td>
<td>Partial Differential Equations</td>
</tr>
<tr>
<td>Applied Functional Analysis</td>
<td>Introduction to Biophysical Modeling</td>
</tr>
<tr>
<td>Physics of Fluids</td>
<td>Functions of a Complex Variable</td>
</tr>
<tr>
<td>Parallel Scientific Computing</td>
<td>Introduction to Atmospheric Science</td>
</tr>
<tr>
<td>Special Topics in Applied Mathematics</td>
<td>Mathematical Methods in Physics</td>
</tr>
<tr>
<td>Asymptotic Methods in Applied Math.</td>
<td>Probability</td>
</tr>
<tr>
<td>Geophysical Fluid Dynamics</td>
<td>Fourier Analysis</td>
</tr>
<tr>
<td>Geophysical Fluid Dynamics Seminar</td>
<td>Analysis and Probability</td>
</tr>
<tr>
<td>Combinatorial Theory</td>
<td>Analysis II</td>
</tr>
<tr>
<td>Numerical Algorithms and Complexity</td>
<td>Mathematical Physics</td>
</tr>
</tbody>
</table>

Source: Columbia University

**Admissions**

Students gain admission to the Applied Mathematics program by applying to one of the university departments that participates in the program. Students must meet the admissions requirements for the department to which they apply, but must also demonstrate a strong background in mathematics. Applicants must submit GRE scores. The average GRE percentiles for students in the graduate programs at the SEAS are 64 for the verbal and writing sections and 82 for the quantitative section. Columbia does not require

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that applicants take the Advanced GRE, but it does strongly urge doctoral applicants to take
the exam – the suggested minimum score on that exam is 680.99

**The University of California, Berkeley**

The University of California, Berkeley offers a Ph.D. in Applied Science and Technology
(AS&T). The major areas of emphasis for the program are applied physics, engineering
science, and mathematical sciences, but the program stresses the value of interdisciplinary
study and allows students to explore a wide range of scientific disciplines.100

**Coursework**

Ph.D. students must complete at least 36 semester units of approved coursework, 24 of
which must be graduate-level courses. Thirty of the required coursework semester units
must be from approved technical courses, and students must complete 18 semester units in
technical courses related to their chosen areas of specialization. Ph.D. students must also
choose a minor emphasis area. Upon admission, students must pass an oral preliminary
exam in their field of expertise.101 The AS&T program also requires that students pass an
oral qualifying examination in subjects related to their areas of study within their first three
years in the program.102 Students must submit and defend an approved dissertation to
complete the Ph.D. degree.103

Students select academic courses with their advisors to develop an appropriate academic
program. The AS&T program does not offer a large number of courses. Rather, students
choose courses from any of the scientific disciplines in which they are concentrating. The
only courses listed by the AS&T department are:

- Soft X-rays and Extreme Ultraviolet Radiation
- Thin Film Science and Technology
- Partially Ionized Plasmas
- Applied Spectroscopy

Faculty members working with the department are experts in myriad scientific disciplines,
including nanostructure device physics, computational biology, magnetic resonance studies
of polymers, and aircraft wake vortices. The vast majority of affiliated faculty come from
engineering or physics departments, although some faculty members hail from chemistry
and mathematics departments.105

**Admissions**

101 “Preliminary Exam.” The University of California at Berkeley. http://ast.coe.berkeley.edu/prospective-
students/preliminary-exam
102 “Qualifying Exam.” The University of California at Berkeley. http://ast.coe.berkeley.edu/prospective-
students/qualifying-exam
103 “Degree Requirements.” The University of California at Berkeley. http://ast.coe.berkeley.edu/prospective-
students/degree-requirements
104 “General Catalog Search Results.” The University of California at Berkeley. http://general-
catalog.berkeley.edu/catalog/gcc_search_sends_request
105 “Faculty.” The University of California at Berkeley. http://ast.coe.berkeley.edu/faculty
The AS&T program seeks applicants who possess a bachelor’s degree or higher in engineering, physics, mathematics, chemistry, or a related discipline. UC Berkeley also expects students to have undergraduate experience in mathematics and science (at least two years of mathematics experience, including vector calculus and differential equations). Students also need at least one year of experience in two of the following sciences: physics, chemistry, or biology. UC Berkeley expects students to have completed upper-division work in mathematics and sciences, as well. \(^{106}\)

\(^{106}\) “Eligibility Requirements.” The University of California at Berkeley. http://ast.coe.berkeley.edu/prospective-students/eligibility-requirements
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