WASHINGTON COLLEGE

March 25, 2020

Dr James D. Fielder
Secretary of Higher Education
Maryland Higher Education Commission
Nancy S. Grasmick Building, 10th Floor
6 North Liberty Street
Baltimore, MD 21201

Dear Dr Fielder,

For many years, Washington College has offered a Bachelor of Arts degree in mathematics. The attached proposal requests that the degree awarded be changed to a Bachelor of Science degree in mathematics. The faculty in the math department have made changes to the major to align our program with recommendations from the Mathematical Association of America. Theses changes will better prepare math majors to work in areas such as data analytics and decision science. This program will now be better suited to award a Bachelor of Science degree rather than the Bachelor of Arts that we are currently approved for.

We believe that offering this major will advance the liberal arts mission of the college and help us attract academically talented students. Like all Washington College majors, the new math major is firmly grounded in the value of liberal learning: analytical thought, clear communication, aesthetic insight, ethical sensitivity and civic responsibility.

The revised mathematics major will require already-existing courses. Washington College is thus very well-positioned to offer this major with existing resources.

Thank you for your consideration; we look forward to hearing from you soon.

Sincerely,

Patrice DiQuinzio
Provost and Dean of the College

300 WASHINGTON AVENUE, CHESTERTOWN, MARYLAND 21620

410-778-2800 | WWW.WASHCOLL.EDU

Office Use Only: PP#

MHEC
Creating a state of achievement

# Cover Sheet for In-State Institutions
# New Program or Substantial Modification to Existing Program

| Institution Submitting Proposal | Washington College |
|---|---|

***Each action below requires a separate proposal and cover sheet.***

- (•) New Academic Program
- ( ) New Area of Concentration
- ( ) New Degree Level Approval
- ( ) New Stand-Alone Certificate
- ( ) Off Campus Program
- ( ) Substantial Change to a Degree Program
- ( ) Substantial Change to an Area of Concentration
- ( ) Substantial Change to a Certificate Program
- ( ) Cooperative Degree Program
- ( ) Offer Program at Regional Higher Education Center

Payment Submitted: (•) Yes ( ) No
Payment Type: ( ) R*STARS (•) Check
Payment Amount: $850.00
Date Submitted: 3/27/20

| | | |
|---|---|---|
| Department Proposing Program | Mathematics | |
| Degree Level and Degree Type | Bachelor of Science | |
| Title of Proposed Program | Mathematics | |
| Total Number of Credits | 128 | |
| Suggested Codes | HEGIS: 170100.00 | CIP: 270101.0000 |
| Program Modality | (•) On-campus | ( ) Distance Education (*fully online*) |
| Program Resources | (•) Using Existing Resources | ( ) Requiring New Resources |
| Projected Implementation Date | (•) Fall ( ) Spring ( ) Summer | Year: 2020 |
| Provide Link to Most Recent Academic Catalog | URL: https://www.washcoll.edu/offices/registrar/college-catalog/ | |
| Preferred Contact for this Proposal | Name: Matthew A. Kibler | |
| | Title: Assistant Vice President of Institutional Effectiveness and Analytics | |
| | Phone: (410) 778-7862 | |
| | Email: mkibler2@washcoll.edu | |
| President/Chief Executive | Type Name: Kurt Landgraf | |
| | Signature:  | 03/23/2020 |
| | Date of Approval/Endorsement by Governing Board: | |

Revised 3/2019

**Proposal for Mathematics to be a B.S. Degree at Washington College**

## A. Centrality to Institutional Mission and Planning Priorities:

1. *Provide a description of the program, including each area of concentration (if applicable), and how it relates to the institution's approved mission.*

   Washington College is currently approved to offer a Bachelor of Arts degree in Mathematics. This proposal seeks to transition the degree to a Bachelor of Science (B.S.) instead of a B.A. The basic BS degree aligns the mathematics major with the contemporary view of mathematics as a critical component of the sciences and engineering. The BS degree creates a student who is well prepared for mathematical research in graduate school or the workplace. The minor provides a well-rounded basic proficiency in mathematics and could be interpreted as the foundational component of the BS in mathematics.

   Enrollment in mathematical courses has been increasing since 2008 and it is usually higher than ten in majors' courses. Many mathematics majors are also double majors in Computer Science, Physics, Chemistry, Biology, Economics, or English. Recently, students have experienced difficulties with meeting the needs of the current BA while pursuing the dual-degree program in engineering due to a large number of physics courses that are not counted towards the requirements of the BA. The new curriculum treats several physics courses and economics courses as applied mathematics courses and makes the BS degree in mathematics a feasible major for dual-degree students; it separately makes earning a second major in Physics feasible, and it introduces richness to the BS in mathematics.

   Systematically incorporating methods of proof in all mathematics courses is a forward step in the amount of rigor that should be a part of a meaningful course of study in mathematics. Discrete Mathematics, which includes coverage of formal logic and proof techniques, will now be required, and will be a pre-requisite for several upper-level courses.

   Lastly, and perhaps most important, the proposed curriculum is aligned with the nine content recommendations in the Mathematical Association of America report. This will update our mathematics major to bring it in line with best practices in mathematics education.

2. *Explain how the proposed program supports the institution's strategic goals and provide evidence that affirms it is an institutional priority.*

Mathematics continues to be a core of superior liberal arts education, critical in multidisciplinary study and key to many of our other curricular endeavors. These updates to the curriculum do not change this. Evidence that this is an institutional priority exists in the number of our staff, including junior faculty in our department and the support for programs like NEXT to develop our faculty into the next generation of excellent teachers in mathematics.

3. *Provide a brief narrative of how the proposed program will be adequately funded for at least the first five years of program implementation. (Additional related information is required in section L.)*

The transition from a B.A. to B.S. can be made to our offerings with no additional funding needed in the foreseeable future. This move is being built out of courses that are already offered or altered in our program with no additional courses or faculty members required.

4. *Provide a description of the institution's a commitment to:*
    a) *ongoing administrative, financial, and technical support of the proposed program*

Courses within this new degree type are already available to students and no new faculty need to be hired. Because of this, the administrative, financial, and technical support needed to support the new degree type are already in place.

    b) *continuation of the program for a period of time sufficient to allow enrolled students to complete the program.*

The major in Mathematics is a longstanding program at Washington College. It is attractive to both prospective students and those students currently enrolled. We foresee continuing this program for many years to come. If by chance the program needed to be discontinued, we would allow sufficient time for students to complete the degree. Courses in the program contribute to our general education requirements and are required by other programs. If we discontinued this program, we would still have to continue offering the courses in some capacity and would allow reasonable time for students in the program to finish.

**B. Critical and Compelling Regional or Statewide Need as Identified in the State Plan:**

1. *Demonstrate demand and need for the program in terms of meeting present and future needs of the region and the State in general based on one or more of the following:*
    a) *The need for the advancement and evolution of knowledge*

    b) *Societal needs, including expanding educational opportunities and choices for minority and educationally disadvantaged students at institutions of higher education*

    c) *The need to strengthen and expand the capacity of historically black institutions to provide high quality and unique educational programs*

The math curriculum presented here supports students who will soon enter a world, driven by data and technology. The inclusion of statistics and computer programming aligns with Committee on Undergraduate Program in Mathematics (CUPM) best practices. Mathematics (and the math major) is attractive to students seeking to push the edge of human knowledge in STEM fields and beyond. As technology and data continues to grow, it demonstrates a continued need for mathematics in our entire educational pipeline. Our success in this program also demonstrates this.

2. *Provide evidence that the perceived need is consistent with the **Maryland State Plan for Postsecondary Education**.*

This curriculum update will align itself with Maryland's State Plan for Postsecondary Education. Specifically, it will increase the quality effectiveness of mathematics education at Washington College. Systematically incorporating methods of proof in all mathematics courses is a forward step in the amount of rigor that should be a part of a meaningful course of study in mathematics. In addition, this incorporation is more fluid, inclusive and gentle. For example, Discrete Mathematics, which includes coverage of formal logic and proof techniques, will now be required, and will be a pre-requisite for several upper-level courses. We also consider this move to be aligning ourselves with goal 4: innovation and goal 6: data use of the plan. By incorporating statistics and programming into the major, students graduating with a mathematics major from Washington College will be better prepared for the technologically dominated and data-driven world that we now live in.

**C. Quantifiable and Reliable Evidence and Documentation of Market Supply and Demand in the Region and State**:

1. *Describe potential industry or industries, employment opportunities, and expected level of entry (ex: mid-level management) for graduates of the proposed program.*
2. *Present data and analysis projecting market demand and the availability of openings in a job market to be served by the new program.*
3. *Discuss and provide evidence of market surveys that clearly provide quantifiable and reliable data on the educational and training needs and the anticipated number of vacancies expected over the next 5 years.*
4. *Provide data showing the current and projected supply of prospective graduates.*

There are many industries and career paths for students who go through our Mathematics program. The chart below gives some examples of potential fields. The average projected growth rate of these fields is 25.8% over the ten years compared to only 5.2% growth for all other occupations. According to the U.S. Bureau of Labor Statistics, the median annual wage for the jobs below is $81,000 to $86,000 compared to a median salary of only $38,640 for all other occupations.

| Occupation Code | Occupation | 2018* | 2028* | Growth |
|---|---|---|---|---|
| 15-2011 | Actuaries | 25 | 30 | 20.1% |
| 15-2021 | Mathematicians | 2.9 | 3.6 | 26% |
| 15-2090 | Miscellaneous mathematical science occupations | 2.3 | 2.4 | 5.6% |
| 15-2031 | Operations research analyst | 109.7 | 137.9 | 25.6% |
| 15-2041 | Statisticians | 44.4 | 58 | 30.7% |
| | **Total** | **184.3** | **231.9** | **25.8%** |

The number of Mathematics majors has been steady for the last five years at Washington College. Enrollment in Mathematics courses is increasing over that same time period. This gives us reason to believe that we will, at least, continue to have the same number of majors in Mathematics, if not increase in that area as well.

| | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | Average |
|---|---|---|---|---|---|---|
| **Mathematic Degrees** | 13 | 12 | 6 | 8 | 11 | 10 |
| **Math Course Enrollment** | 518 | 544 | 601 | 584 | 604 | 570 |

The chart below gives the number of Mathematics graduates at similar institutions in the state and at institutions outside of the state that we consider to be peers. It is evident that others see the same consistency in their Mathematics program that we do at Washington College. These numbers coupled with the data from Washington College give us reason to believe that we will continue to have a healthy supply of Mathematics graduates in the coming years.

| Number of Graduates | | | | | | |
|---|---|---|---|---|---|---|
| **MD Private Institutions** | **2014** | **2015** | **2016** | **2017** | **2018** | **Average** |
| Goucher College | 5 | 0 | 4 | 10 | 5 | 5 |
| Hood College | 5 | 11 | 10 | 15 | 5 | 9 |
| McDaniel College | 8 | 5 | 6 | 7 | 8 | 7 |
| Mount Saint Mary's University | 10 | 5 | 5 | 3 | 7 | 6 |
| Stevenson University | 5 | 8 | 7 | 0 | 3 | 5 |
| **Peer Institutions** | | | | | | |
| Albion College | 6 | 7 | 5 | 5 | 10 | 7 |
| Juniata College | 11 | 8 | 7 | 7 | 10 | 9 |
| Lake Forest College | 4 | 17 | 11 | 10 | 17 | 12 |
| Muhlenberg College | 14 | 25 | 17 | 17 | 18 | 18 |
| Transylvania University | 11 | 7 | 8 | 8 | 6 | 8 |
| Washington & Jefferson College | 10 | 11 | 7 | 7 | 14 | 10 |

**D. Reasonableness of Program Duplication:**

1. *Identify similar programs in the State and/or same geographical area. Discuss similarities and differences between the proposed program and others in the same degree to be awarded.*
2. *Provide justification for the proposed program.*

Our program is similar to other institutions in the state and region. Examples were given in part c. We are not adding this as a new program but making modifications to better fit the needs of our current students and to stay in line with recommendations from national mathematical societies.

**E. Relevance to High-demand Programs at Historically Black Institutions (HBIs)**

1. *Discuss the program's potential impact on the implementation or maintenance of high-demand programs at HBI's.*

The transition from a B.A. to a B.S. will have no impact on programs at HBI's. We are making the change to an already approved Mathematics program. We won't see an increase in our Washington College student enrollment as a result of making this change. The purpose of the transition is to recognize the changes in national trends of mathematics degrees.

**F. Relevance to the identity of Historically Black Institutions (HBIs)**

1. *Discuss the program's potential impact on the uniqueness and institutional identities and missions of HBIs.*

This transition, as proposed, is common for Mathematics programs and does not reflect the uniqueness and institutional identities and missions of HBIs. We are not adding content to our curriculum, rather, we are giving students a more appropriate degree for the coursework they are completing.

**G. Adequacy of Curriculum Design, Program Modality, and Related Learning Outcomes** (as outlined in COMAR 13B.02.03.10):

1. *Describe how the proposed program was established, and also describe the faculty who will oversee the program.*

The mathematics program at Washington College is a long-standing major. Classes within the Mathematics Department are always highly enrolled. The department provides service to other programs at the college but also consistently has a respectable number of majors relative to the size of Washington College. The Chair of the Math and Computer Science department oversees the program. Currently the chair of the department is Shaun Ramsey, Ph.D.

2. *Describe educational objectives and learning outcomes appropriate to the rigor, breadth, and (modality) of the program.*

Students who complete the Bachelor of Science in Mathematics program will become proficient in the following learning outcomes:

- Students will learn the fundamental skills and ideas of major areas of mathematics
- Students will develop communication skills, both written and oral, to describe mathematics to wide and diverse audiences.
- Students will develop a broad foundation of reasoning and analytical skills that can be applied to many fields, including mathematics.
- Students will develop the ability to write and analyze mathematical proofs
- Students will understand the societal impact and ethical implications of mathematics and its applications.

3. *Explain how the institution will:*
    a) *provide for assessment of student achievement of learning outcomes in the program*
    b) *document student achievement of learning outcomes in the program*

Student learning outcomes will be assessed through two processes. Our Student Learning Outcomes Assessment process is conducted annually by every department. In addition, we have a procedure for assessing learning outcomes for our general education requirements. Departments and coordinators for the general education learning outcomes must document the assessments and submit them to the Assessment Committee. These reports are then delivered to necessary stakeholders and archived on the Institutional Research website for internal purposes and future accreditation requirements.

4. *Provide a list of courses with title, semester credit hours and course descriptions, along with a description of program requirements*

The Mathematics program requires students to complete both the institution's distribution requirements as well as the program specific requirements. A description of the Washington College distribution requirements is attached as Appendix A. The course catalog entry for the Mathematics program is attached as Appendix B. It details the specific requirements of the program and concentration and has course descriptions for courses with a MAT heading. Detailed course descriptions for each of the courses that are part of the program but do not have a MAT heading are listed in Appendix C.

A list of courses that students can choose to fulfill the requirements of the Mathematics program from both the Mathematics program and other programs with their course number, title, and semester credit hours is included here for quick reference (full course descriptions are in Appendix B and C):

| ***Course Number*** | ***Course Name*** | ***Credits*** |
|---|---|---|
| MAT 109 | Statistical Inference & Data Analysis | 4 |
| MAT 108/110 | Stretch Differential Calculus (two semester sequence) | 8 |
| MAT 111 | Differential Calculus | 4 |
| MAT 112 | Integral Calculus | 4 |
| MAT 210 | Multivariable Calculus | 4 |
| MAT 240 | Discrete Mathematics | 4 |
| MAT 280 | Linear Algebra | 4 |
| CSI 100 | Basics of Computing | 4 |
| CSI 201 | Computer Science I | 4 |
| PHY 252 | Scientific Modeling and Data Analysis | 4 |
| MAT 410 | Abstract Algebra | 4 |
| MAT 470 | Real Analysis I | 4 |
| MAT 230 | Foundations of Geometry | 4 |
| MAT 310 | Differential Equations | 4 |
| MAT 320 | Probability | 4 |
| MAT 330 | Complex Analysis | 4 |

| | | |
|---|---|---|
| MAT 340 | Numerical Analysis | 4 |
| MAT 350 | Theory of Numbers | 4 |
| MAT 480 | Real Analysis II | 4 |
| CHE 305 | Chemical Thermodynamics and Chemical Dynamics | 4 |
| CHE 306 | Quantum Chemistry and Spectroscopy | 4 |
| CSI 380 | Analysis of Algorithms | 4 |
| CSI 320 | Theory of Computation | 4 |
| PHY 321 | Classical Mechanics | 4 |
| PHY 324 | Electricity and Magnetism | 4 |
| PHY 322 | Quantum Physics | 4 |
| ECN 320 | Econometrics | 4 |
| MAT 391,392,491, 492 | Math Seminar (1 credit each for 4 semesters) | 4 |
| | | |

5. *Discuss how general education requirements will be met, if applicable.*

Students within the Mathematics program will have the same General Education requirements, called distribution requirements, as all other programs. As stated in the College Catalog, Washington College's liberal arts and sciences commitment means that students explore many areas of interest and develop the capacity to reason, to appreciate literature and the arts, and to make the connection between courses of study and their implications in society. To ensure this broad intellectual foundation, Washington College has established a set of guidelines concerning its General Education, which include:

- a required, four credit, first-year seminar course called the Global Perspectives Seminar (GRW 101)
- a Writing Program containing four requirements (known as W1-W4) that move from the first year through the senior capstone experience
- the Foreign Language requirement (0 – 2, four credit courses depending on incoming proficiency level)
- three, four credit courses distributed between the Natural Sciences and a Quantitative skills course, to include at least one laboratory course and at least one Quantitative course
- three, four credit courses in the Humanities and Fine Arts, including at least one course from each
- three, four credit courses in the Social Sciences including courses from two different departments
- students will have approximately 24 additional credits that they can take outside of the general education requirements and mathematics requirements, these can be used for a minor in another department, a double-major, or elective

The first- and second-year general education requirements are designed to introduce students to an intellectual community and give them the basis to declare a major that focuses on one or more disciplines.

All MAT courses count towards the quantitative distribution except in one case. The 2-semester Stretch Differential Calculus sequence will count as two courses toward the quantitative distribution component but taking only one semester will not count for any.

Course descriptions for each of these courses can be found in Appendix B within the catalog entry for Mathematics.

6. *Identify any specialized accreditation or graduate certification requirements for this program and its students.*

Not applicable

7. *If contracting with another institution or non-collegiate organization, provide a copy of the written contract.*

Not applicable

8. *Provide assurance and any appropriate evidence that the proposed program will provide students with clear, complete, and timely information on the curriculum, course, and degree requirements, nature of faculty/student interaction, assumptions about technology competence and skills, technical equipment requirements, learning management system, availability of academic support services and financial aid resources, and costs and payment policies.*

The entire Mathematics catalog entry is attached as Appendix B. It is made available on the Washington College website at www.washcoll.edu. The catalog gives students clear and complete details about the requirements of the program. Course descriptions include prerequisites. Faculty regularly provide students information about the learning management system and academic support services in their syllabi. In addition, both of our instructional technologists, who are responsible for our LMS, and staff in our academic support areas regularly communicate with students to inform them of the services their offices provide. Financial aid and cost resources are made available to students on the financial aid section of our website and business office section of our website. In addition, students are able to be in touch directly with these offices in person, by phone, or by email whenever they have questions.

9. *Provide assurance and any appropriate evidence that advertising, recruiting, and admissions materials will clearly and accurately represent the proposed program and the services available.*

Our Enrollment Management team works directly with faculty when they are putting together advertising and/or admissions materials to be sure that information is clear and accurate. The Mathematics website will also be a major resource for students. At Washington College, all websites are maintained by the individual departments. This helps to ensure that content is accurate and relevant for anyone who visits the site.

**H. Adequacy of Articulation**

1. *If applicable, discuss how the program supports articulation with programs at partner institutions. Provide all relevant articulation agreements.*

Not Applicable

**I. Adequacy of Faculty Resources** (as outlined in COMAR 13B.02.03.11).

1. *Provide a brief narrative demonstrating the quality of program faculty. Include a summary list of faculty with appointment type, terminal degree title and field, academic title/rank, status (full-time, part-time, adjunct) and the course(s) each faulty member will teach (in this program).*

The mathematics major is long-standing and the faculty are more than adequate. At Washington College, we teach a variety of courses throughout our curriculum rather than a few select one or two classes per professor. Tenure and tenure-track faculty with PhDs comprise the majority of our staffing with a diversity of personalities and perspectives. Expertise in data science, engineering, operations research, number theory, combinatorics, graphics, programming and more are fundamental to creating an atmosphere of rich and vibrant ideas. These culminate in rich and exciting senior capstone projects with the students, as well as a variety of special topics courses. A summary of our faculty in the department and some courses they have offered are provided at the beginning of the following page.

| Faculty Name | Degree | Title & Rank | Status | Courses |
|---|---|---|---|---|
| Shaun Ramsey | PhD – Computer Science | Chair, Associate Professor, Tenured | Full-time | MAT 210, MAT 109, CSI 201, CSI 350 |
| Austin Lobo | PhD – Computer Science | Associate Professor, Tenured | Full-time | MAT 111, 112, CSI 370 |
| Dylan Poulsen | PhD – Mathematics | Assistant Professor, Tenure Track | Full-time | MAT 210, 280, 310, 320, 340, 410, 470, 480 |
| Gabe Feinberg | PhD – Mathematics | Assistant Professor, Tenure Track | Full-time | MAT 111, 112, 210, 240, 340, 410 |
| Kyle Wilson | PhD – Applied Mathematics | Assistant Professor, Tenure Track | Full-time | MAT 112, CSI 100, 201, 370 |
| Emerald Stacy | PhD – Mathematics | Assistant Professor, Tenure Track | Full-time | MAT 108, 110, 111, 350 |
| Jordan Tirrell | PhD – Mathematics | Assistant Professor, Tenure Track | Full-time | MAT 109, MAT 240, MAT 340 |
| Jesse Andrews | M.S. – Mathematics | Full-time Instructor | Full-time | MAT 111, 112, 230, 240, 330, 410 |
| Kerrin Ehrensbeck | M.Ed. – Education with a focus in Mathematics | Director of Quantitative Skills Center | Full-time | MAT 109 |

2. *Demonstrate how the institution will provide ongoing pedagogy training for faculty in evidenced-based best practices, including training in:*
    a) *Pedagogy that meets the needs of the students*

Currently, faculty members have access to a variety of professional development and pedagogical training opportunities at Washington College. All faculty members are eligible for annual conference travel funds. Junior faculty receive support for project NExT, a professional development program for new PHDs in mathematics to improve teaching and scholarship as well as provide service and professional opportunities. Faculty also have access to the Washington College Center for Teaching and Learning that offers a wide variety of programming on pedagogical development as well as Faculty Enhancement Funds that are used to further the scholarly pursuits of faculty members. We are departmental members of MAA which provide access to some journals, and other journals are available through the library. There is no shortage of opportunities and funds to help keep our faculty up-to-date with pedagogy, best teaching practices and scholarships.

    b) *The learning management system*

Washington College has two full-time Instructional Technologists that are responsible for management of Canvas, our learning management system. They hold workshops throughout the year for faculty to provide training on the new features that are available as well as provide refreshers on commonly used pieces. Additionally, during new faculty orientation, faculty members are introduced to the Instructional Technologists and the services they provide. The Instructional Technologists are available throughout the year to meet with faculty about how best to incorporate the learning management system into their courses.

    c) *Evidenced-based best practices for distance education, if distance education is offered.*

We do not offer any distance education courses.

**J. Adequacy of Library Resources** (as outlined in COMAR 13B.02.03.12)**.**

1. *Describe the library resources available and/or the measures to be taken to ensure resources are adequate to support the proposed program.* ***If the program is to be implemented within existing institutional resources****, include a supportive statement by the President for library resources to meet the program's needs.*

This program will be implemented using existing institutional resources. A statement of support from our President, Kurt Landgraf, addressing both this piece of the proposal and section K.1. is included in our submission application after the appendices.

**K. Adequacy of Physical Facilities, Infrastructure and Instructional Equipment** (as outlined in COMAR 13B.02.03.13)

1. *Provide an assurance that physical facilities, infrastructure and instruction equipment are adequate to initiate the program, particularly as related to spaces for classrooms, staff and faculty offices, and laboratories for studies in the technologies and sciences. If the program is to be implemented within existing institutional resources, include a supportive statement by the President for adequate equipment and facilities to meet the program's needs.*

This program will be implemented using existing institutional resources. A statement of support from our President, Kurt Landgraf, addressing both this piece of the proposal and section J.1. is included in our submission application after the appendices.

2. *Provide assurance and any appropriate evidence that the institution will ensure students enrolled in and faculty teaching in distance education will have adequate access to:*

   a) *An institutional electronic mailing system, and*
   b) *A learning management system that provides the necessary technological support for distance education*

Not Applicable

**L. Adequacy of Financial Resources with Documentation** (as outlined in COMAR 13B.02.03.14)

1. *Complete **Table 1: Resources and Narrative Rationale**. Provide finance data for the first five years of program implementation. Enter figures into each cell and provide a total for each year. Also provide a narrative rationale for each resource category. If resources have been or will be reallocated to support the proposed program, briefly discuss the sources of those funds.*

Table 1 represents the total resources coming into the Mathematics program. In putting this proposal together, we assume a modest increase in tuition of 2% over the next five years will be the reason for the availability of additional resources. The number of F/T students is given based on the current number of students who have declared Mathematics as their major.

| **TABLE 1: RESOURCES:** | | | | | |
|---|---|---|---|---|---|
| **Resources Categories** | **Year 1** | **Year 2** | **Year 3** | **Year 4** | **Year 5** |
| 1. Reallocated Funds | 0 | 0 | 0 | 0 | 0 |
| 2. Tuition/Fee Revenue (c + g below) | $ 1,193,088 | $ 1,216,930 | $ 1,241,292 | $ 1,266,122 | $ 1,291,446 |
| a. Number of F/t Students | 26 | 26 | 26 | 26 | 26 |
| b. Annual Tuition/Fee Rate | $ 45,888 | $ 46,805 | $ 47,742 | $ 48,697 | $ 49,671 |
| c. Total F/T Revenue (a x b) | $ 1,193,088 | $ 1,216,930 | $ 1,241,292 | $ 1,266,122 | $ 1,291,446 |
| d. Number of P/T Students | 0 | 0 | 0 | 0 | 0 |
| e. Credit Hour Rate | 0 | 0 | 0 | 0 | 0 |

| | | | | | |
|---|---|---|---|---|---|
| f. Annual Credit Hour Rate | 0 | 0 | 0 | 0 | 0 |
| g. Total P/T Revenue (d x e x f) | 0 | 0 | 0 | 0 | 0 |
| 3. Grants, contracts, & Other | 0 | 0 | 0 | 0 | 0 |
| 4. Other Sources | 0 | 0 | 0 | 0 | 0 |
| Total (Add 1-4) | $ 1,193,088 | $ 1,216,930 | $ 1,241,292 | $ 1,266,122 | $ 1,291,446 |

2. *Complete **Table 2: Program Expenditures and Narrative Rationale**. Provide finance data for the first five years of program implementation. Enter figures into each cell and provide a total for each year.*

Program expenditures are built using only budgetary expenses directly associated with Mathematics. For example, even though the program has requirements outside of the Mathematics Department, only faculty directly in the Mathematics program are represented in the table. Faculty who teach classes in other departments that can count towards the degree are not included here because our budget is not constructed in that way.

The transition from B.A. to B.S. will not require any additional staffing. The increase in salary below represents the projection of a modest 2% per year cost of living adjustment.

| **TABLE 2: EXPENDITURES:** | | | | | |
|---|---|---|---|---|---|
| **Expenditure Categories** | **Year 1** | **Year 2** | **Year 3** | **Year 4** | **Year 5** |
| 1. Faculty (b + c below) | $ 634,443 | $ 647,131 | $ 660,074 | $ 673,275 | $ 686,741 |
| a. #FTE | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 |
| b. Total Salary | $ 507,554 | $ 517,705 | $ 528,059 | $ 538,620 | $ 549,393 |
| c. Total Benefits | $ 126,889 | $ 129,426 | $ 132,015 | $ 134,655 | $ 137,348 |
| 2. Admin. Staff (b + c below) | $ 18,750 | $ 19,125 | $ 19,508 | $ 19,898 | $ 20,296 |
| a. #FTE | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| b. Total Salary | $ 15,000 | $ 15,300 | $ 15,606 | $ 15,918 | $ 16,236 |
| c. Total Benefits | $ 3,750 | $ 3,825 | $ 3,902 | $ 3,980 | $ 4,059 |
| 3. Support Staff (b + c below) | $ 51,893 | $ 52,931 | $ 53,989 | $ 55,069 | $ 56,170 |
| a. #FTE | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 |
| b. Total Salary | $ 41,514 | $ 42,344 | $ 43,191 | $ 44,055 | $ 44,936 |
| c. Total Benefits | $ 10,379 | $ 10,586 | $ 10,798 | $ 11,014 | $ 11,234 |
| 4. Equipment | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 |
| 5. Library | $ 1,300 | $ 1,300 | $ 1,300 | $ 1,300 | $ 1,300 |
| 6. New or Renovated Space | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 |
| 7. Other Expenses | $ 7,700 | $ 7,700 | $ 7,700 | $ 7,700 | $ 7,700 |
| TOTAl (Add 1-7) | $ 714,085 | $ 728,187 | $ 742,571 | $ 757,242 | $ 772,207 |

**M. Adequacy of Provisions for Evaluation of Program** (as outlined in COMAR 13B.02.03.15).

1. *Discuss procedures for evaluating courses, faculty and student learning outcomes.*
2. *Explain how the institution will evaluate the proposed program's educational effectiveness, including assessments of student learning outcomes, student retention, student and faculty satisfaction, and cost-effectiveness.*

The Mathematics program will continue to be subject to the same requirements for assessment and evaluation as existing programs. All Washington College students complete course evaluations at the end of each of their courses. The results of these evaluations are delivered to department chairs and the Dean and Provost of the College for use in tenure and promotion decision making.

Washington College has worked hard to ensure that the assessment activities we pursue are actually meaningful and help us improve the teaching and learning priorities that we identify as being most important. We have established a regular practice of assessment that is manageable and sustainable. Every year each department completes a Student Learning Outcomes Assessment (SLOA) report that outlines measurable objectives, describes how assessment data are captured, and presents student learning outcomes data. It also summarizes changes that the departments have made in response to previous assessment. In addition, every three years, each department submits Department Program Assessment and Planning (DPAP) reports in which they reflect on the programmatic strengths and challenges of the previous three years and set a plan for moving forward. While SLOA reports focus on student learning outcomes, DPAP reports provide an opportunity to focus on issues other than student learning outcomes, such as enrollment growth, changes in the field, and strategic academic priorities.

**N. Consistency with the State's Minority Student Achievement Goals** (as outlined in COMAR13B.02.03.05).

1. *Discuss how the proposed program addresses minority student access & success, and the institution's cultural diversity goals and initiatives.*

The recruitment and retention of minority students is a priority for Washington College. In fall 2015, 12.8% of undergraduates were minority students and 5.2% African American. The good news for the College is that the diversity of incoming classes has been steadily increasing, even exceeding 20% for first-time, full-time students in fall 2016. That trend is consistent today with our institution still maintaining a 20% minority student population.

Washington College is committed to minority student access and success. We have hired an admissions counselor who's focus is on minority student recruitment. We have an Office of Intercultural Affairs with two professional staff members that support our minority students on campus as well as provide programming to educate the entire campus community. Faculty, staff, and students were invited to a diversity training in January. We also have a diversity committee on campus that has faculty, staff, and student members.

**O. Relationship to Low Productivity Programs Identified by the Commission:**

1. *If the proposed program is directly related to an identified low productivity program, discuss how the fiscal resources (including faculty, administration, library resources and general operating expenses) may be redistributed to this program.*

Not Applicable

**P. Adequacy of Distance Education Programs** (as outlined in COMAR 13B.02.03.22)

1. *Provide affirmation and any appropriate evidence that the institution is eligible to provide Distance Education.*

Not Applicable

3. *Provide assurance and any appropriate evidence that the institution complies with the C-RAC guidelines, particularly as it relates to the proposed program.*

Not Applicable

Appendix A: Distribution Requirements

Students are required to complete courses from the four categories listed below, unless a waiver is granted on the basis of Advanced Standing credits (AP, CIE, CLEP, or IB) or Transfer Credit equivalency. Other than the Natural Science component, combining courses from two departments to satisfy part of a distribution requirement is not allowed without permission from the chairs of the two departments involved. This permission must be obtained by the student and submitted in writing to the Associate Provost for Academic Services before the student takes the second of the two courses. Students may not use a single course to satisfy more than one distribution requirement simultaneously. However, courses offered to satisfy distribution requirements may also count toward any number of major or minor requirements.

I. Foreign Language Requirement – Students must complete one or two courses in a foreign language depending on their placement level.
II. Natural Science and Quantitative Requirement – Students must complete three courses, with at least one satisfying the Natural Science component and another satisfying the Quantitative component. The third course is the student's option but must follow a set of pairing rules. Generally, this means students take the second course in the sequence of either their Natural Science or Quantitative component choice.
III. Humanities and Fine Arts Requirement – Students must complete three courses, with at least one satisfying the Humanities component and another satisfying the Fine Arts component. The third course is the student's option but must follow a set of pairing rules. Generally, this means students take the second course in the sequence of either their Humanities or Fine Arts component choice.
IV. Social Science Requirement – Students must complete three courses, with at least two from the same department.

**Appendix B: Catalog Language**

# Mathematics and Computer Science

Division of Natural Sciences and Mathematics
Shaun Ramsey, Chair
Jesse Andrews
Kerrin Ehrensbeck
Gabriel Feinberg
Eugene Hamilton
Austin A. Lobo
Dylan Poulsen
Emerald Stacy
Jordan Tirrell
Kyle Wilson

The Mathematics and Computer Science Department's curriculum gives students technical knowledge along with a broad foundation of reasoning and analytical skills that can be applied to many fields. Graduates can pursue graduate work in computer science or mathematics, teach in secondary schools, work as professionals in government and industry, or use quantitative and computing techniques in the natural sciences or social sciences. All students must master the relevant basic mechanical concepts necessary to perform the fundamental operations related to mathematics or computer programming. The learning environment places emphasis on reasoning, problem-solving, and communications skills. Students are required to make oral presentations in classes and at seminars and to write detailed papers and reports for regular classes and for their Senior Capstone projects.

## Freshman/Sophomore Courses

In mathematics, the six foundational courses shown below are the gateway to the major; the analogous sequence for computer science consists of CSI 201, CSI 202, and CSI 203. Prospective majors should begin coursework in these sequences in their first semester at the College.

The Department strongly advises students not to take a course unless they received a grade of C or better in the prerequisite course.

## Requirements for a Bachelor of Science in Mathematics

Normally a student with good preparation in mathematics who intends to major in mathematics or one of the natural sciences will start in the calculus sequence with MAT 111, but a student who has had some work in calculus or who has received advanced placement credit for calculus may start with a more advanced course, and is encouraged to consult with the department chair to make such arrangements. Students who would like a slower introduction to calculus may take the Stretch Differential Calculus sequence in place of MAT 111.

Appendix B: Mathematics Catalog Language

Mathematics majors are eligible for the teacher education program. In order to assure proper scheduling, students wishing to become certified to teach mathematics should inform the chairs of both the Mathematics and Computer Science and Education Departments as soon as possible.

The mathematics major is also compatible with extended courses of study such as the Combined Plan in Engineering at Columbia University, where students will take several upper-level math classes. As such, these students will have portions of the major waived, as noted below. Specifically, they can take fewer electives and can forgo writing a senior thesis or taking comprehensive exams.

The major in mathematics consists of a minimum of eleven courses: six foundational courses, a computing course, an advanced course, and three electives; plus an SCE and attendance at the Math Seminar.

1. All six of the following foundational courses:

MAT 109 Statistical Inference & Data Analysis
MAT 111 Differential Calculus or the Stretch Calculus Sequence MAT 108/110
MAT 112 Integral Calculus
MAT 210 Multivariable Calculus
MAT/CSI 240 Discrete Mathematics
MAT 280 Linear Algebra

2. One of the following computing courses:

CSI 100 Basics of Computing
CSI 201 Computer Science I
PHY 252 Scientific Modeling and Data Analysis

3. One of the following advanced courses:

MAT 410 Abstract Algebra
MAT 470 Real Analysis I

4. Three additional elective courses, at least one of which must be a MAT course. (Students successfully completing an approved extended course of study in an engineering program may complete only two of the following, at least one of which is a MAT course):

MAT 230 Foundations of Geometry
MAT 310 Differential Equations
MAT 320 Probability
MAT 330 Complex Analysis
MAT 340 Numerical Analysis

MAT 350 Theory of Numbers
MAT 410 Abstract Algebra (if not counted as the advanced course above)
MAT 470 Real Analysis I (if not counted as the advanced course above)
MAT 480 Real Analysis II
Any Special Topics course in mathematics at the 200-level or above
CHE 305 Chemical Thermodynamics and Chemical Dynamics
CHE 306 Quantum Chemistry and Spectroscopy
CSI 370 Analysis of Algorithms
CSI 350 Theory of Computation
PHY 321 Classical Mechanics
PHY 324 Electricity and Magnetism
PHY 322 Quantum Physics
ECN 320 Econometrics
Appropriate special topics in other departments (subject to approval by the dept. chair)

5. Four semesters of the Math Seminar (MAT 391, 392, 491, and 492). Each course is one credit hour, and the sequence begins in the fall of a student's junior year. (Accommodations will be made for study abroad and teaching semesters as granted by the dept. chair).

6. A Senior Capstone Experience (SCE), which can take the form of one of the following:

- A year-long research project culminating in a written thesis, expository or containing original research, to be completed during the senior year. A student pursuing departmental honors must complete a thesis.
- Completion of comprehensive exams covering material from foundational courses.
- Completion of an approved extension course of study such as the Combined Plan in Engineering at Columbia University.

**The Minor in Mathematics**

The minor in mathematics consists of
- Five foundational courses excluding statistics,
- One advanced course (MAT 410 or MAT 470), and
- One elective from the list above

With a few exceptions, any MAT or CSI course can be counted for distribution. In particular: The 2-semester Stretch Differential Calculus sequence will count as two courses toward the quantitative distribution component but taking only one semester will not count for any. Designated MAT special topics classes may be excluded. Please read the catalog entries carefully.

Appendix B: Mathematics Catalog Language

| Course #/name | Description |
|---|---|
| MAT 102 Chaos and Fractals | This course is an introduction to the rapidly developing science of complexity. It is a discussion of the tools—fractals, chaos, and self-organization—being refined for the purpose of understanding such things as the fractured and irregular structures of Nature, surprise and unpredictability, and the emergence of lifelike properties from inanimate matter. The theme of the course is that complexity can arise from simple origins, such as the repeated application of elementary processing rules. The course emphasizes the use of the computer for visualization. Practical application of these ideas in medicine and engineering will be discussed, as will examples of the connections between complexity in the sciences and that in the humanities and the arts. |
| MAT 104 Finite Mathematics | Linear programming, matrices, sets and counting, Markov process, difference equations, and graphs. The course will emphasize developing, analyzing, and interpreting mathematical models. |
| MAT 105 Communication, Patterns, and Inventions in Mathematics | This course is designed for students in the Elementary Education Certification Program and for students planning to complete the Secondary Education Certification Program in an area other than mathematics. The framework of the course consists of four themes: Number Systems and their Operations, Algebra and Functions, Geometry and Measurement, Data Analysis, Statistics, and Probability. Emphasis throughout is on reasoning and problem-solving using concepts and procedures from all four areas. Substantial amounts of both reading and writing will be required and students will be expected to demonstrate both orally and in writing a thorough understanding of the concepts and the ability to communicate this understanding to others. |
| MAT 109 Statistical Inference & Data Analysis | Introduction to the appropriate methods for analyzing data and designing experiments. After a study of various measures of central tendency and dispersion, the course develops the basic principles of testing hypotheses, estimating parameters, and reaching decisions. *Credit for MAT 109 will not be given if taken before or subsequently to BUS 109, PSY 209, or ECN 215.* |
| MAT 108/110 Stretch Differential Calculus | A two semester sequence in differential calculus. Topics include analytic geometry, the derivative and differential, elementary functions, limits, continuity and applications. Students are encouraged to take this two course sequence based on their prior experience with relevant mathematical topics. Completion of this two-course year-long sequence is equivalent to the completion of MAT 111. |
| MAT 111 Differential Calculus | Analytic geometry, the derivative and differential, elementary functions, limits, continuity and applications. *Prerequisite: It is strongly recommended that a student should have taken a high-school course in both algebra and trigonometry.* |

Appendix B: Mathematics Catalog Language

| | |
|---|---|
| MAT 112<br>Integral Calculus | The indefinite integral, the definite integral, the fundamental theorem of the integral calculus, sequences, series and applications. *Prerequisite:* MAT 111 *or permission of the instructor.* |
| MAT 210<br>Multivariable Calculus | Vectors, partial derivatives and multiple integrals for functions of several variables. Line and surface integrals. *Prerequisite:* MAT 112 *or permission of the instructor.* |
| MAT 230<br>Foundations of Geometry | A critical study of the basic concepts of geometry. This course begins with an axiomatic approach to Euclidean geometry which includes careful proofs of its principal theorems. The course will continue with an examination of various types of non-Euclidean geometries which may include spherical geometry, projective geometry, and/or hyperbolic geometry. *Prerequisite:* MAT 112 *or permission of the instructor.* |
| MAT 240<br>Discrete Mathematics (Cross-listing of CSI 240) | An introduction to logic, reasoning, and the discrete mathematical structures that are important in computer science. Topics include proposition logic, types of proof, induction and recursion, sets, combinatorics, functions, relations, and graphs. |
| MAT 252 | Cross Listed with PHY 252 |
| MAT 280<br>Linear Algebra | An introduction to linear algebra balancing computation and the reading, understanding, and writing of mathematical proofs. A selection of topics from systems of linear equations, matrices, vector spaces, bases, dimension, linear transformations, determinants, eigenvalues, change of basis, matrix representations of linear transformations, matrix decompositions, and applications of linear algebra. It is recommended that students take MAT 240 before this course. *Prerequisite*: MAT 112 *or permission of the instructor*. |
| MAT 310<br>Differential Equations | Elementary methods for the solution of ordinary differential equations, including the expansion of the solution in an infinite series. *Prerequisite:* MAT 210 *or permission of the instructor.* |
| MAT 320<br>Probability | Events and their probabilities, dependence and independence. Bayes' theorem. Variates and expected values. Theorems of Bernoulli and De Moivre. Special distributions. Central limit theorem and applications. *Prerequisite*: MAT 112. |

Appendix B: Mathematics Catalog Language

| | |
|---|---|
| MAT 330<br>Complex Analysis | Theory of functions of a complex variable, including applications to the problems in the theory of functions of a real variable. Cauchy's Integral Formula and its application to the calculus of residues. *Prerequisite*: MAT 210 *or permission of the instructor.* |
| MAT 340<br>Numerical Analysis | Solution of equations and systems of equations by iteration and elimination, numerical differentiation and integration, assessment of accuracy, methods of interpolation and extrapolation. *Prerequisite:* MAT 210 *or permission of the instructor.* |
| MAT 350<br>Theory of Numbers | Factorization of integers. congruences and residue classes. Theorems of Euler, Fermat, Wilson, and Gauss. Primitive roots. Quadratic residues and the reciprocity theorem. *Prerequisite:* MAT 112*.* |
| MAT 410<br>Abstract Algebra | Introduction to groups, rings and fields. Other topics may include integral domains, polynomial rings, and fields. *Prerequisite:* MAT 280 *and mathematical maturity as demonstrated by the completion of* MAT 240 *or permission of the instructor.* |
| MAT 470<br>Real Analysis I | A rigorous treatment of single-variable calculus. A selection of topics from the properties and the topology of the real numbers, sequences, series, continuity, differentiation, and Riemann integration. *Prerequisite:* MAT 210 *and mathematical maturity as demonstrated by completion of one of* MAT 240, *or* MAT 280, or *permission of the instructor.* |
| MAT 480<br>Real Analysis II | A continuation of Real Analysis II. Topics selected according to student and instructor interest. Topics could include: analysis in metric spaces, analysis in n-dimensional space, Fourier analysis, functional analysis, measure theory, and Lebesgue integration. Suitable for engineers, chemists, physicists, economists, and mathematicians. *Prerequisite:* MAT 470 |
| MAT 390, 490<br>Mathematics Internship | Open to mathematics majors only. *Prerequisite:* MAT 112*, minimum of rising junior standing, and permission of the Department.* |
| MAT 391, 392<br>Junior Seminar | Open to mathematics majors only. Weekly meetings of the majors and faculty in the department are scheduled to provide information about careers, graduate school, thesis topics, and research areas, as well as to prepare each major to make presentations of problem solutions and to make the required presentation on the thesis. All junior mathematics majors are enrolled in the seminar and will receive a pass/fail grade at the end of the semester. *Junior standing, and permission of the Department.* |

Appendix B: Mathematics Catalog Language

| | |
|---|---|
| MAT 491, 492 Senior Seminar | Open to mathematics majors only. Senior students will make a presentation of a preliminary outline of their capstone project in the fall semester and will present a report on the completed capstone project in the spring. All senior mathematics majors are enrolled in the seminar and will receive a pass/fail grade at the end of the semester. *Prerequisite*: *Senior Standing,* MAT 391/392 *and permission of the Department.* |
| MAT 194, 294, 394, 494 Special Topics | |
| MAT 295, 395, 495 On-campus Mathematics Research | A close interaction between a student and a faculty mentor based upon a proposal developed collaboratively to conduct investigations into theoretical or applied mathematics with or without computational content. A final public report detailing findings is required. *Prerequisite:* MAT 112*, sophomore, junior, or senior standing, and permission of the Department.* |
| MAT 396, 496 Off-campus Mathematics Research | Open to mathematics majors only. A close interaction between a student and an off-campus mentor based upon a proposal developed collaboratively to conduct investigations into theoretical or applied mathematics with or without computational content. A final public report and a public presentation about the research at the departmental seminar are required. *Pre-requisite:* MAT 112*, departmental junior or senior standing, and permission of the Department.* |
| MAT 297, 397, 497 Independent Study | The study of areas of mathematics that are not covered in regularly scheduled courses. The instructor and student will meet weekly to discuss progress. *Pre-requisite:* MAT 112*, departmental sophomore, junior or senior standing, and permission of the Department.* |
| MAT SCE Senior Capstone Experience | The Senior Capstone Experience in mathematics consists of four problem credits earned during the junior seminar, plus a senior thesis on theoretical or applied mathematics with or without computational content, plus two oral presentations on the thesis at the senior mathematics seminars. The senior capstone in mathematics will be graded Pass, Fail, or Honors. |

**CHE 305. Chemical Thermodynamics and Chemical Dynamics** Thermodynamics is the study of the behavior of matter and the transformation between different forms of energy on a macroscopic scale. Chemical dynamics is the study of the rate at which the macroscopic properties and composition of matter change. These changes can involve either transport properties, such as thermal conductivity, viscosity, and diffusion or chemical kinetics. Some of the chemical kinetics topics covered are rate laws, temperature effects on reaction rates, reaction rate theories, reaction mechanisms, and enzyme catalysis. Applications of chemical thermodynamics and chemical dynamics are drawn from environmental chemistry and biochemistry. Laboratory exercises include determination of thermodynamic properties and kinetics experiments. Three hours of lecture and three hours of laboratory each week. Prerequisite: Chemistry 112 and Mathematics 202 or Chemistry 220, and Mathematics 202. Co-requisite: Physics 111 or Physics 101. (Offered annually: Fall)

**CHE 306. Quantum Chemistry and Spectroscopy** Quantum chemistry is the application of quantum mechanics to the field of chemistry. Topics included in the discussion of quantum chemistry are the early development of quantum mechanics, quantum mechanical models for molecular vibrations and rotations, and electronic structure of atoms and molecules. Spectroscopy is the study of the interactions of electromagnetic radiation with matter, and is the principal experimental tool used to investigate the predictions made using quantum mechanics. The laboratory exercises include spectroscopy experiments and the use of molecular modeling programs. Three hours of lecture and three 77 Chemistry hours of laboratory each week. Prerequisite: Chemistry 112 and Mathematics 202 or Chemistry 220 and Mathematics 202. Co-requisite: Physics 112 or Physics 102. (Offered annually: Spring)

**PHY 252. Scientific Modeling and Data Analysis** This course serves as a focused introduction to programming for scientists and engineers. Topics include algorithm development, statistical tests, the fast Fourier transform (FFT), simulating the dynamics of systems represented by coupled ordinary differential equations (e.g. planetary motion via Runge-Kutta methods), numerical integration, root finding, fitting functions to experimental data, and the creation of publication-quality graphics. Students choose and complete an independent research project on a topic related to their major. This course enables students to integrate computation into advanced courses in theoretical and/or experimental science. Programming language: Python. Co-requisite: MAT 202. 247

**PHY 321. Classical Mechanics** Kinematics and dynamics of particles and rigid bodies. Topics include: Conservation laws, central forces, motion in non-inertial frames, small oscillations, and Lagrangian and Hamiltonian equations of motion. Prerequisite: PHY 211, PHY 252 and MAT 345, or permission of the instructor.

**PHY 322. Quantum Mechanics** An introduction to the fundamental principles of quantum mechanics: quantum states and the principle of superposition, probability distributions and expectation values, observables and operators, operator representations, and perturbation theory. There will be a discussion of selected applications of the theory to atomic, solid state, and nuclear physics. Prerequisite: PHY 211, PHY 252 and MAT 345, or permission of the instructor.

Appendix C: Catalog Description for Courses Outside the Math Department

**PHY 324. Electricity and Magnetism** Electric and magnetic fields in vacuum. A survey of experiments and theory leading to Maxwell's equations. Topics include: electrostatics, electric currents, magnetic fields, electromagnetic induction, Maxwell's equations, and electromagnetic waves. Prerequisite: PHY 211, PHY 252 and MAT 345, or permission of the instructor.

**CSI 100. Basics of Computing** This course introduces computer programming in a modern, high-level programming language. Objectives include proficiency in the language (including variables, functions, types, flow control, and basic data structures) as well as familiarity with common computer science problem solving strategies. Students will also gain experience in team programming and in program design for practical problem solving. This course counts for distribution but does not count towards the major in computer science.

**CSI 201. Computer Science I** The objectives of this course are threefold: (a) to introduce problem-solving methods and algorithmic development; (b) to teach an object-oriented programming language; and c) to teach how to design, code, debug, and document programs in an object oriented environment using techniques of good programming style.

**CSI 350. Theory of Computation** Formal models of computation such as finite state automata, pushdown automata, and Turing machines will be studied along with corresponding formal languages, e.g., regular languages and context-free languages. Uncomputability, including the halting problem, and computational complexity including the classes P and NP and NP-completeness will be studied. Prerequisite: Computer Science 202 and Computer Science 240.

**CSI 370. Design and Analysis of Algorithms** The topic of this course is the design of computer algorithms and techniques for analyzing their efficiency and complexity. Types of algorithms include greedy algorithms, divide and conquer algorithms, dynamic programming, searching and sorting. Prerequisite: Computer Science 202, Computer Science 240.

**ECN 320. Econometrics** This course introduces the statistical tools that economists use to test and quantify their theories. Regression analysis is used to evaluate relationships between economic variables. The results are interpreted with the help of concepts like causality and significance. Prerequisite: Economics 111 or 112, and Math 109 or Economics 215.