Department: Mathematics and Computer Science

Chairperson: ____________________________________________

(Signature)

Department Approval: ________________________ April 11, 2005__

(Date of departmental meeting)

This is a __X__ new program ___modification of existing program requirements.

**Summary Description of Proposal:**

The purpose of this proposal is to establish an interdisciplinary minor in Computational Science. Computational Science is an interdisciplinary field of study at the intersection of applied mathematics, statistics, and the natural, cognitive, social and managerial sciences. The study of Computational Science provides a critical connection between mathematics and science and will expose our students to modern computational techniques used to apply models and extract information from data. The proposed computational science minor consists of 13 hours of core courses and 8 or 9 hours or courses selected from options designed to support students from a wide array of disciplines. Since most of the requirements are already part of the course repertoire at Loyola, this new interdisciplinary minor represents a small investment in resources with great return potential.
I. JUSTIFICATION FOR THE PROGRAM OR CHANGE: provide a clear and compelling rationale for any proposed curriculum modification, including additions and deletions to the course inventory, changes in degree/program requirement, new degree programs, and other major curriculum revisions. The justification should state explicitly and clearly how the changes relate to the Academic Plan for Loyola University and the Academic Plan for the College of Arts and Sciences.

INTRODUCTION AND RATIONALE

Computational Science is an interdisciplinary field of study at the intersection of applied mathematics, statistics and the natural, cognitive, social and managerial sciences. Computational Science seeks to take advantage of the recent profusion of powerful computational tools to enable the acquisition and organization of data and develop and apply models to extract information from observation. The recent development of powerful computational tools including numeric, symbolic, statistical, database and visualization software is enabling rapid advancements in the analytical description of complex systems. In addition, the study of Computational Science provides for students a critical connection between mathematics and science. For Loyola University to remain competitive in attracting students interested in the sciences, it is imperative that our students be exposed to these modern computational techniques.

This Curriculum Proposal seeks approval for a minor degree program in Computational Science. This program will be primarily targeted at students in the natural and social sciences seeking to use modern computational techniques in their field of study. The goals of this program are to enhance students’ abilities to

- Understand and do science
- Understand and apply numerical methods of problem solving
- Understand and apply statistical analyses
- Understand and apply computational tools used in the acquisition and analysis of complex data sets
- Understand, develop and apply scientific models

Although primarily targeted to science students, the proposed computational science minor is designed to be attractive to prospective students and to be attainable in any discipline. The course requirements are logical, incremental and flexible enough to be completed in a typical curriculum. Since most of the requirements are already part of the course repertoire at Loyola, its creation will represent a minor investment in resources with great return potential.

JUSTIFICATION FOR THE PROGRAM

LINKAGE TO UNIVERSITY/COLLEGE DEPARTMENTAL PLANS

The proposed Computational Science minor will enhance the quality of the educational experiences that Loyola provides to students. The proposal directly supports Departmental, College, and University Academic Plans. In addition, the Computational Science minor
strengthens important elements of critical thinking, information literacy, and interdisciplinary learning, as mentioned in Loyola’s Pathways Plan.

University Academic Plan

The Pathways Plan states “In undergraduate education Loyola will continue to be grounded in the liberal arts and sciences. The university will provide high quality inter-disciplinary approaches to learning that seek the integration of research and teaching.” Computational Science is a growing and inherently interdisciplinary discipline. Problems in Computational Science often require teams of researchers with different specialties working together to better understand a complex system or to solve difficult problems. Our Computational Science minor will introduce students to basic techniques and tools used in Computational Science and will provide them with the opportunity to work on interdisciplinary research projects as undergraduate students. Furthermore, Pathways states “To assure that this academic vision becomes reality, the university will develop programs to support research by faculty and students. This will support knowledge creation, a particularly important area for Loyola as it adapts to a new knowledge-based economy and world.” This proposed program thus serves the future needs of our students.

Loyola’s strategic plan includes the following goals, objectives, and action plans that are directly addressed by the minor in Computational Science proposal.

Goal: Excel in educating students as whole persons.

- Enhance the educational experience for students.
  - The university will develop innovative approaches to enhancing critical thinking, ethical reasoning, and more effective communication skills in the Jesuit tradition of a liberal education.
  - Ensure all students develop strategies for enhancing critical thinking skills. Complete by June 2009.
  - Ensure that all students acquire information literacy by June 2009.
- Increase interdisciplinary teaching.
  - In 2008-2009, the university will implement five additional interdisciplinary courses. The university will develop plans for two new interdisciplinary programs.
  - In 2009-2010, the university will assess new interdisciplinary courses and will implement two new interdisciplinary programs.
- Innovatively integrate technology into learning activities.

The minor in Computational Science will provide a path for students to further develop their critical thinking skills. Students in the minor will be engaged in learning to solve complex problems introduced in their major courses by employing methodologies learned in mathematics classes. In this way, Computational Science provides a bridge between mathematics and science courses. Currently, students will commonly learn concepts and methodologies in a mathematics class without realizing their application to problems in the sciences. For example, most students completing one semester of calculus can find the minima and maxima of a given function but are lost in science classes when, given a probability distribution, are asked to determine the most likely outcome. Providing students with the experience of applying mathematics and statistics to real-world problems in the
sciences will greatly enhance students abilities to think critically and analytically when problem solving.

Loyola’s strategic plan sets as a goal the development new interdisciplinary programs. This interdisciplinary minor in Computational Science will be jointly hosted by the Departments of Biological Sciences, Chemistry, Mathematics, Physics, and Psychology. At least one course in the program will be team-taught by faculty members from different departments. Indeed, the very nature of the program is interdisciplinary in that it seeks to enhance students’ abilities to use computational methods to apply mathematical methodologies to solve problems in the natural and social sciences. Computational Science will provide an interdisciplinary atmosphere where students can explore the use of computers to apply mathematics to solve problems from fields as diverse as theoretical physics, synthetic chemistry, field biology, economics, and social science.

Clearly the study of Computational Science will facilitate the integration of technology into learning activities. Currently, students in the sciences rarely reach for anything more sophisticated than a scientific calculator when problem solving. One aim of this program is to make students more fluent and comfortable in the use of computational techniques and, more specifically, advanced numeric and symbolic software packages when problem solving. These technologies greatly increase the speed and flexibility with which data sets may be analyzed and/or modeled and make more sophisticated models accessible to undergraduate students. Visualization of mathematical models is also critical to student understanding and developing their ability to think critically and analytically.

College of Humanities and Natural Sciences Strategic Plan

The College of Humanities and Natural Sciences includes the following goals, objectives, and action plans that are directly addressed by the minor in Computational Science proposal. iv

Goal One: As charged by the Loyola University Mission Statement, the College remains “grounded in the liberal arts and sciences,” and exemplifying the rich, Jesuit traditions of liberal arts education, it continues to offer innovative Curricular and Co-Curricular programs that meet the needs of its students.

3. The College will enhance and expand both currently supported and proposed interdisciplinary minors and majors in several areas, including Africana Studies, American Studies, Asian Studies, Catholic Studies, Computational Sciences (emphasis added), Environmental Studies, Latin American Studies, Medieval Studies, and Women’s Studies; it will also support and expand linked theme courses across the disciplines.

Furthermore, the College Strategic Plan establishes its commitment to the development of these programs by providing resources as deemed appropriate and necessary.

Departmental Strategic Plans

The proposed minor in Computational Science also supports the strategic plans of the departments of Mathematics, Biology, Chemistry, Physics, and Psychology. The Mathematics Department seeks to develop modern, up-to-date and current curricula that
serve the post graduate need of our students.” The Biology Department seeks to “increase the quantitative skills of students and build linkages to related fields.” The Chemistry Department plans to “Continue to Build Undergraduate Research Infrastructure into Sciences at Loyola.” The Physics Department is interested in offering computational physics for their students and the research component of this Computational Science minor is an excellent way to address this need. Finally, the Psychology Department Strategic Goal 6 seeks to increase the information and technological literacy of psychology students.

THE MINOR IN COMPUTATIONAL SCIENCES

The minor in Computational Science will consist of 13 hours of core courses and 8 or 9 hours of courses (including at least 2 hours of research*) selected from options designed to support students from a wide array of disciplines. The program will be administered by a committee consisting of one faculty member each from the departments of Mathematics, Chemistry, Physics, Biology, and Psychology.

CORE COURSES 13 hours

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<thead>
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<tbody>
<tr>
<td>Math 211 Intro to Programming I</td>
<td>3</td>
<td>NO</td>
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<td>Math 257 Calculus I</td>
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<td>NO</td>
</tr>
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<td>3</td>
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<td>Math 375 Computational Mathematics</td>
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OPTIONS 8 or 9 hours, including at least 2 hours of research*

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Option 3

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<tbody>
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<td>Psych 303 Statistics and Methods OR Math 260 Statistical Inference for Scientists OR DECS 205 Business Statistics</td>
<td>3</td>
<td>NO</td>
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<td>Research OR Math 212 Intro to Programming II</td>
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<tr>
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*Research means computational research to be completed in one of the research labs in the sciences or in applied computational mathematics. Research completed in support of the minor in Computational Science will be approved and reviewed by the Computational Science Committee (see Section V Assessment Plan) to ensure that the research sufficiently involves the use of computational techniques.
II. IMPACT ON THE CURRICULUM:

A. Review your current course offerings and requirements in light of the proposed change. How will the proposed change or changes improve your program and enhance the educational outcomes you seek to accomplish?

Most of the courses and options listed as part of the Computational Science minor are already available in the current inventory of courses at Loyola.

The proposed Computational Science minor will enhance the quality of the educational experiences of students at Loyola and will allow Loyola to compete with our peer institutions in the recruitment and retention of excellent students. We expect this minor will help attract the best and brightest students and improve the retention of these students to graduation.

B. How will proposed change impact the major/adjunct/elective hour distribution requirement for the major or program? For new or significantly revised programs, provide a detailed description of the major/adjunct/elective elements of the curriculum, including copies of the old and new DPCLs.

The minor in Computational Science will consist of 13 hours of core courses and 8 or 9 hours of courses (including at least 2 hours of research*) selected from options designed to support students from a wide array of disciplines. The program will be administered by a committee consisting of one faculty member each from the departments of Mathematics, Chemistry, Physics, Biology, and Psychology.

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*Research means computational research to be completed in one of the research labs in the sciences or in applied computational mathematics. Research completed in support of the minor in Computational Science will be approved and reviewed by the Computational Science Committee (see Section V Assessment Plan) to ensure that the research sufficiently involves the use of computational techniques.


Math A271 is truly an innovative addition to this program and to similar programs at other institutions. This course will be team-taught, and will incorporate laboratory data collection, computer interfacing, and data analysis. It will utilize and build on topics and methodologies learned in other mathematics and science courses to achieve interdisciplinary integration, transfer of concepts across disciplines, and optimal learning outcomes.

Math A375 is an introduction to common numerical methods typically used in Computational Sciences. These techniques include root finding, linear systems, numerical differentiation and integration, and curve fitting. It is essential that computational scientists be familiar with these methodologies. This course will replace the current Mathematics adjunct course COSC A375 Numerical Algorithms.
III. IMPACT OF NEW PROGRAM ON FREQUENCY OF COURSE OFFERINGS:

A. Specify whether any new courses will be offered, and whether this will increase the total number of courses or sections offered by the department.

Two new courses will be developed in support of the Computational Science minor: Math A271 Applied Scientific Computing and Math A375 Computational Mathematics. It is expected that these courses can be easily scheduled into the regular mathematics course offerings.

Math A271 will be team-taught. At least for the first two times the course is offered, both faculty members would receive full credit for teaching this course.

B. If new courses will not increase the overall number of offerings, specify which course(s) or section(s) will be dropped in a given semester to create room.

The Mathematics Department is currently working on curriculum revisions which would result in the discontinuation of Math A204 Discrete Mathematics as a requirement. Also, Math A375 will replace COSC A375 for Mathematics majors with an emphasis in computations. The proposed new courses can be implemented in place of Math A204 and COSC A375.

C. Specify any anticipated impact on enrollments in other courses or sections within the department and whether or not this program will prevent an important or required course from being offered in a given semester.

The minor in Computational Science would have no effect on enrollments in other courses or sections within the science departments. The requirements of this minor will not prevent any other course from being offered in any given semester.

D. Assess the impact of the proposed change on other departments, especially those serviced by your department or program and those that provide adjunct service to your department or program.

The proposed Computational Science minor will not negatively affect any other department. It is expected that this new program will enhance the ability of all science departments to recruit and retain excellent students.

E. All proposals must be accompanied by a supporting letter from the chair confirming the department’s support. Those proposing an interdisciplinary Minor program must submit, in addition to the letter of support from the department chair, a letter of support from the advisory committee chair of that program. This letter should certify that the advisory committee approves the proposed program as submitted.

These letters are attached.

IV. IMPACT ON THE BUDGET:

A. Staffing. Is current staffing sufficient or will new faculty be needed (whether full-time or part-time)?

No new science faculty staff would be needed to accommodate the needs of the proposed Computational Science minor.
As start up support for the program, we will ask the Dean of Humanities and Natural Sciences to grant a course release for the chair of the Computational Science Minor Committee to develop an exciting website for the minor with links to all undergraduate research opportunities in the sciences. The goal is for this website to serve as a recruitment tool for incoming students. In addition, the chair will work closely with our faculty and with the Admissions office to inform and help in the recruitment process.

B. Support services. Will the proposed change require additional support services (Media Center audio/visual: typing/secretarial, computer services, computer time)?

The proposed Computational Science minor will not require additional support services. There is a need to enhance the quality of these services, but that largely lies outside of this proposal (i.e., there is a university-wide need to create and support electronic classrooms). The Computational Science minor would continue to require strong support by these units.

C. New equipment. Does the proposed change presuppose the purchase of new equipment, whether for support or instruction?

The proposed Computational Science minor does not require the purchase of new equipment. Equipment needed for this program has already been provided through funding from an NSF grant.

D. Additional physical space. Does the proposed change require additional physical space (for classes or labs) or modifications of existing physical plant space?

No additional physical space or modifications of existing physical plant space are needed.

E. Impact on other departments. How will the proposed change impact the staffing, equipment, and service budgets of other departments?

As stated in point C, the proposed Computational Science minor will not require new resources of other departments. Additionally, this minor presents additional opportunities to pursue external grants for interdisciplinary studies.

Faculty members in different departments have already been successful in obtaining external grants in Computational Science. For example, Dr. Lynn Koplitz in Chemistry has received an NSF grant in Computational Chemistry. Dr. Maria Calzada in Mathematics has received an NSF grant to pursue interdisciplinary studies in Mathematics and Chemistry. This minor will enhance our ability to receive further grants in interdisciplinary studies.

V. ASSESSMENT PLAN:

Provide a detailed plan for assessment of the proposed program. According to what criteria will its success be measured? What tools/instruments will you employ? How often will assessment take place? What mechanisms will be in place to ensure continuous improvement?
The Computational Science Minor Committee, a committee of faculty members from all the natural science departments, will have the primary responsibility for the assessment of the program. The committee will measure the success of the program in several ways:

- **Recruitment and retention of new students into the program**
  It is expected that the new program will attract additional students into Loyola and into our science departments. We will create a website describing the program and the different possibilities for undergraduate research in the sciences, which make our departments unique. The additional possibility of engaging in interdisciplinary studies and research in this emerging field, computational science, should spur interest in attending Loyola by students attracted to scientific computing. With our help, admissions counselors should be able to measure an increased interest in the sciences at Loyola. The close interaction between our faculty and our students should result in improved student persistence and graduation rates. Specifically, within the first five years of implementation we expect to count on 15-20 new Computational Science minors.

- **Peer evaluation of course materials**
  As part of on-going faculty development activities, the Computational Science Committee members will attend Computational Science sessions in their respective professional conferences to continuously evaluate programs and courses offered at different institutions. This information will be shared with the committee and periodic revisions will be implemented in our courses and program.

- **Committee evaluation of computational science research projects**
  Our Computational Science minor culminates with the capstone experience of performing interdisciplinary computational research. As can be seen from the options described in part IB, a student will spend between 2 and 5 credit hours doing this type of research. The student will be required to write a research proposal which will be approved by the committee. Students will also be required to produce a written report detailing their efforts and results while performing the research. The committee will evaluate the overall and individual quality of the research projects and will act to assure continuous improvement of the process. Students will present their research results at a seminar.

- **Success of our graduates in graduate school and in the work force**
  We will keep connected with our Computational Science minors after they graduate and will assess through their experiences the quality of our program. Our graduates will have valuable information that we will use to evaluate and improve our program.

VI. **NEW COURSE PROPOSALS:**

Detailed course proposals for any new courses to be created should be submitted, in proper form, each with a Course Proposal cover sheet, and including complete course syllabi.

Syllabi for the new courses can be found on the following pages. For each course, the College of Humanities & Natural Sciences Curriculum format is used and a functional syllabus included.
Department: Mathematics and Computer Science

Chairperson: ____________________________ (Signature)

Department Approval: _____________ April 11, 2005__________
(Date of departmental meeting)

Course Title: Applied Scientific Computing
(Limit 24 Spaces)

Course Number: MATH – A271

Term: Fall X or Spring X Summer __

Credit Hours: 3 required of minor

Requirement: _____ Culture _____ Ethnic _____ Gender and/or _____ Environmental
(At least 50% of the course must meet one of these criteria in order to meet the requirement)

Pre-requisites: Math A257 (Math A211 recommended) or instructor permission

Course Description: (maximum 350 spaces)

This course introduces students to techniques and methods commonly used by scientists to analyze, build models, visualize and make decisions based on data collected in laboratory and field experiments. It emphasizes the interdisciplinary nature of scientific computing by applying the mathematical tools of statistics and numerical computations to hands on experiments from diverse areas of science.
Syllabus for Math A271, Applied Scientific Computing  
Spring 2009

Pre-requisites: Math A257 (Math A211 recommended) or instructor permission

Instructors: Drs. Maria Calzada (Mathematics) and Thomas Spence (Chemistry)

Office Information: To be included here

Course Objectives: Using computational environments such as Matlab and Labview, this course introduces students to techniques and methods commonly used by scientists to analyze, build models, visualize and make decisions based on data collected in laboratory and field experiments.

Course Outcomes: Upon completion of the course students will be able to
- Acquire and computer interface data
- Analyze data using a variety of computational tools
- Build computer programs to perform analyses and construct models
- Effectively communicate the results of the analysis using analytical, numerical, written, and graphical representations.

Text: Numerical Computing with Matlab by Cleve B. Moler

Topics: The course will include a number of the numerical topics listed below, studied within the realm of real applications and using laboratory experiments as motivation. Other topic may be substituted depending on needs of students and the interest of the instructors.
- Error analysis
- Root finding
- Curve fitting
- Linear systems
- Numerical calculus
- Monte Carlo simulation
- Fourier Transforms

Assignments: In addition to regular homework assignments, there will be at least 5 laboratory projects which will integrate the mathematical techniques studied with laboratory data. Possible projects include:
- Error analysis, t-test and ANOVA: Measuring density of soft drinks
- Curve fitting: Newton’s Law of cooling, constrained growth
- Linear systems: simultaneous equilibria
- Numerical calculus: Bond calorimetry
- Monte Carlo simulation: Cyclic voltammetry
- Fourier transforms: Nuclear Magnetic Resonance (NMR)

Course Grade: The grade will be determined based on your performance on the laboratory projects, a midterm exam and a final exam. The projects will account for 60% of your grade, and the midterm and final 20% each. The following grade scale will be used:
- 90-100 -> A  87-89 -> B+  80-86 -> B  77-79 -> C+  70-76 -> C
- 67-69 -> D+  60-66 -> D  0-59 -> F
To receive full credit on a project, it must be turned in on its due date. Every day that a project is late it will lose 10% of its grade. If you have a documented medical excuse for missing an exam, your exam score will be based on an additional project. If you do not have a documented excuse for missing an exam, you will receive a zero for that exam. The final exam is cumulative.
**Attendance:** Attendance is mandatory. At the end of the semester grades will be dropped by the number of missing class days. For example, consider a student who achieved a 93 as final average and say this student missed four classes. This student’s final average will be lowered to an 89 and will get B+ instead of an A.

**Students with disabilities:** A student with a disability that qualifies for accommodations should contact Sarah Mead Smith, Director of Disability Services at 865-2990 (Academic Resource Center, Room 405, Monroe Hall). A student wishing to receive test accommodations (e.g., extended test time) should provide the instructor with an official Accommodation Form from Disability Services in advance of the scheduled test date.

**Blackboard:** This course has a blackboard site at http://loyno.blackboard.com. Grades, homework, projects and announcements will be periodically posted through this site. E-mails will also be distributed through this site. It is expected that you will receive emails posted through this site.
Department: Mathematics and Computer Science

Chairperson: ____________________________  (Signature)

Department Approval: ______ April 11, 2005 ______  (Date of departmental meeting)

Course Title: Computational Mathematics  
(Limit 24 Spaces)

Course Number: MATH – 375

Term:  Fall X  or  Spring X  Summer __

Credit Hours:  3 required of minor

Requirement: _____ Culture _____ Ethnic _____ Gender and/or _____ Environmental  
(At least 50% of the course must meet one of these criteria in order to meet the requirement)

Pre-requisites: Math A211 and Math A257 or instructor permission

Course Description: (maximum 350 spaces)

This course develops the computational procedures, which are fundamental to numeric applications. The topics studied will be selected from but not limited to error analysis, numerical solutions of non-linear equations, systems of linear equations using direct and iterative methods, polynomial interpolation, quadrature, least squares curve fitting, and numerical solutions of ordinary differential equations. This course will not count as a Mathematics elective for the Mathematics major. It is a requirement for the Computational Mathematics major and the Computational Science minor.
Syllabus for Math A375, Computational Mathematics
Fall 2009

Pre-requisites: Math A211 and Math A257 or instructor permission

Instructors: Dr. Xuefeng Li

Office Information: To be included here

Course Objectives: This course develops the computational procedures, which are fundamental to numeric applications.

Course Outcomes: Upon completion of the course students will be able to
- Understand and apply basic approximations to diverse areas of mathematics
- Apply different approaches to solve problems.
- Use technology as a problem solving tool.
- Communicate the substance, meaning and limitations of their numerical solutions.


Topics: The topics studied will be selected from but not limited to error analysis, numerical solutions of non-linear equations, systems of linear equations using direct and iterative methods, polynomial interpolation, quadrature, least squares curve fitting, and numerical solutions of ordinary differential equations.

Assignments: There will be three exams, written homework, projects and a final exam.

Course Grade: Tests will account for 30% of the grade. Written homework and projects will account for 55% of your grade. The cumulative final exam will account for 15% of the grade. The following grade scale will be used:

- 90-100 -> A
- 87-89 -> B+
- 80-86 -> B
- 77-79 -> C+
- 70-76 -> C
- 67-69 -> D+
- 60-66 -> D
- 0-59 -> F

To receive full credit on a written homework or project, it must be turned in on its due date. Every day that a project is late it will lose 10% of its grade. If you have a documented medical excuse for missing an exam, your exam score will be based on the other exams. If you do not have a documented excuse for missing an exam, you will receive a zero for that exam. The final exam is cumulative.

Attendance: Attendance is mandatory. At the end of the semester grades will be dropped by the number of missing class days. For example, consider a student who achieved a 93 as final average and say this student missed four classes. This student’s final average will be lowered to an 89 and will get B+ instead of an A.

Students with disabilities: A student with a disability that qualifies for accommodations should contact Sarah Mead Smith, Director of Disability Services at 865-2990 (Academic Resource Center, Room 405, Monroe Hall). A student wishing to receive test accommodations (e.g., extended test time) should provide the instructor with an official Accommodation Form from Disability Services in advance of the scheduled test date.

Blackboard: This course has a blackboard site at http://loyno.blackboard.com. Grades, homework, projects and announcements will be periodically posted through this site. E-mails will also be distributed through this site. It is expected that you will receive emails posted through this site.


