X Change Request

New Experimental Course Proposal

Date Submitted: 08/24/18 11:22 am

Viewing: **MATH 481 / MATH 581X**

Numerical Methods for Differential Equations

Last edit: 11/05/18 10:14 am

Last edited by: slh

Changes proposed by: luos

In Workflow

1. Registrar pre-check
2. MATH Curr Chair
3. MATH Chair
4. slh
5. LAS Coordinator
6. Grad Coordinator
7. Scheduling

Catalog Pages referencing this course	**MATH 481:** Biochemistry and Biophysics Computer Engineering Computer Engineering (CPR E) Computer Science

College	Liberal Arts and Sciences
Department	MATH - Mathematics
Course Number	581X
Catalog Year	2018-2019
First Expected Offering Term	Spring
Instructor	Songting Luo

Title
Numerical Methods for Differential Equations

Primary or Lead Department	MATH - Mathematics
Dual Listed Courses	MATH 481
Cross Listed Courses	

Course Details

Credit Hour Details	Credit Type	Credit Hours

Fixed 3

Grading Method A-F

Instruction Type

Instruction Type	Contact Hours per Week
Lecture	3

Repeatable? No | Maximum number of times or credits for this course that can appear on the transcript. | Options

Semesters Offered Spring: Yes Annually

Prerequisites
MATH 265; and either MATH 266 or MATH 267; knowledge of a programming language is helpful.

Description
MATH 581X introduces basic numerical methods for solving differential equations. Topics include: First order Euler method, high order Runge-Kutta methods, and multistep methods for solving ordinary differential equations. Finite difference and finite element methods for solving partial differential equations. Local truncation error, stability, and convergence for finite difference method. Numerical solution space, polynomial approximation, and error estimate for finite element method. Computer programming required.

Meets U.S. Diversity Requirement? No

Meets International Perspectives Requirement? No

Special Fee? No

Do you propose that the course be acceptable for General Education Requirement credit?

No

Syllabus & Supporting Documentation

MATH581X-Content-Grading.pdf
duallisted-MATH581X-MATH481_updated Nov 5.doc

Reason for proposal (programmatic justification, need for course, intended use, etc.)

The course is meant to serve as a beginning graduate course on numerical methods for differential equations, where the topics are relatively easier to understand for applied mathematics graduate students, including the graduate students for the newly established Postbaccalaureate Certificate in Mathematics program, who do not have extensive experience on numerical analysis and scientific computation related to differential equations. It will therefore not only prepare the students for taking more advanced applied mathematics courses, but also prepare the students who are interested in Computational and Applied Mathematics for future research.

Course outcomes/objective

This course covers the numerical solution of differential equations, both ordinary and partial differential equations (DEs). The material divides into 3 large topics: ODEs, finite difference methods for PDEs, and finite element methods for PDEs. For each major topic, we will spend roughly 5 weeks.

At the end of this course, the student should have gained an overview of the major types of methods used to solve ODEs and PDEs, and understand the underlying mathematical principles. He or she should be able to select appropriate software for a given problem, and solve the problem numerically. The student should also be able to understand the limits of the methods and software, and be able to judge the accuracy of the numerical solution.

Course content/major topics to be addressed (attach syllabus if by your college/department)

Please refer to the attached outline.

Assessment Plans: Mechanism for assessing student mastery of course outcomes/objectives

The course grade will be based on homework sets and one or two exams.
There will be differential expectations for graduate students (for 581 credit) and undergraduate students (for 481 credits); that is, some additional problems and reading assignment will be required for graduate students in each homework set.

Relationship of this course to existing courses in other departments and programs (supporting, overlap, etc.)

No overlap with the courses offered by other departments. This course will be dual-listed with MATH 481 that prepares undergraduate students who are interested in Computational and

Applied Mathematics with Applications. Students from all the Colleges, especially Engineering and Liberal Arts and Sciences, are very interested in such topics.

Results of consultation with relevant departments and programs

No departments were consulted. None needed.

Course reviewer comments

keinert (09/11/18 2:28 pm): This course already exists as Math 481. The proposal is to cross-list it as Math 581, as part of the new post-baccalaureate program in Math.

Key: 1477
Preview Bridge

IOWA STATE UNIVERSITY
GRADUATE COLLEGE

Dual-Listed Courses

Departments must request permission to offer courses at the graduate level in conjunction with 300-400 level undergraduate courses. The request is made to the Graduate Curriculum and Catalog Committee. If the dual-listed courses are also experimental courses (400X/500X), submit the experimental course form to the Scheduling Office, 10 Enrollment Services, AND attach an approved copy of the experimental course form(s) to the dual –listed request.

> Dual-listed courses permit undergraduate and graduate students to be in the same class but to receive credit under two different course numbers. Credit in the graduate course is not available to students who have received credit in the corresponding undergraduate course. Both graduates and undergraduates receive the same amount of credit for the course, but additional work is required of all graduate students taking the course under the graduate-level course number. This extra work may take the form of additional reading, projects, examinations, or other assignments as determined by the instructor. The instructor must be a member of the Graduate Faculty or a Graduate Lecturer. Each dual-listed course is designated in the catalog with the phrase "Dual-listed with," although the student's official transcript of credits, both graduate and undergraduate, does not identify dual-listed courses as such. There is a limit to the number of dual-listed course credits that may be used to meet the requirement for an advanced degree. (For information about procedures for requesting permission to offer dual-listed courses, faculty should consult the *Graduate Faculty Handbook*.).

In reviewing proposals for dual-listed courses, this committee needs to understand the department's rationale for offering the course. When a department submits a request, an explanation should be given of the purpose served by the course and the criteria used by the department to determine if the course is suitable for dual-listing. Please submit the proposal in electronic form as a word attachment to grad_college@iastate.edu.

The following information should be included in the proposal:

1. Full catalog information for each course to be dual-listed, including the course numbers (or proposed course numbers), title, credits, semester offering (if applicable), prerequisites, and description. Dual-listed courses bear common numbers, e.g., 580 (480).

MATH 581X. Numerical Methods for Differential Equations.
(3-0) Cr. 3. S. Prereq: MATH 265 and either MATH 266 or MATH 267

First order Euler method, high order Runge-Kutta methods, and multistep methods for solving ordinary differential equations. Finite difference and finite element methods for solving partial differential equations. Local truncation error, stability, and convergence for finite difference method. Numerical solution space, polynomial approximation, and error estimate for finite element method. Computer programming required.

MATH 481. Same description and credits as above. MATH 481 is an existing course.

2. Graduate faculty status of the proposed instructor.

Songting Luo is an associate professor in the department of mathematics, has been an active graduate faculty since 2012, regularly teaches both undergraduate and graduate courses relative to numerical analysis, and does research in numerical analysis and differential equations.

3. Number of the dual-listed course credits the department will permit to be used to meet the requirements for an advanced degree. This limit includes dual-listed courses taken in all departments.

There does not seem to be a departmental policy. In recent years few mathematics graduate students have taken dual listed courses.

4. The differential expectations for graduate students and undergraduates. What additional work will be required for graduate students enrolled in the course? Please describe this work, not in abstract terms (such as "more in-depth participation") but in terms of concrete measurable outcomes or other tangible evidence. Welcome inclusions: specific examples of the additional assignments with details about paper length; the number of additional readings; the length and frequency of oral presentations; portfolio expectations; indications of how these graduate requirements are weighted in the course grade (ex. 40% of final grade); comparisons with undergraduate expectations.
   Examples:
   - Graduate students are required to research a topic and write an in-depth paper.
   - Graduate students are required to attend additional lectures, and have (X) extra assignment papers (to be determined).

This is a graduate course with full graduate expectations for graduate students and reduced expectations for undergraduate students. All students are required to complete homework assignments and projects that include both theoretical and programming problems. The homework assignments and projects will be collected, graded, and used to calculate final course grades.

For programming problems, graduate students are required to produce their own computer codes with Matlab or any other softwares to implement the numerical methods for solving the problems. Undergraduate students may have access to some of the sample codes for the numerical methods, from which they can modify the codes to solve the problems.

Tentative Grading Policy for MATH 581X:

There will be 4 homework projects and one comprehensive final project.

The homework projects will be assigned approximately every 3 weeks according to the progress of the class. Each project will have both theoretical and programming problems. For the programming problems, the students are required to produce their own computer codes to implement the numerical methods for solving the problems.

The comprehensive final project will have two parts. One part will be an in-class exam that contains theoretical problems. The other part will be a programming project that contains programming problems. The students are required to produce their own computer codes to implement the numerical methods for solving the problems.

The 4 homework projects will count for 80% of the course grade, and the comprehensive final project will count for 20% of the course grade.

Tentative Grading Policy for MATH 481:

There will be 4 homework projects and one comprehensive final project.

The homework projects will be assigned approximately every 3 weeks according to the progress of the class. Each project will have both theoretical and programming problems. For the programming problems, the students may have access to some sample codes of the numerical methods that are needed in the problems. The students will need to study the sample codes and make necessary modifications for solving the problems.

The comprehensive final project will have two parts. One part will be an in-class exam that contains theoretical problems, with open discussions. The other part will be a programming project that contains programming problems. The students may have access to some sample codes of the numerical methods that are needed in the problems. The students will need to study the sample codes and make necessary modifications for solving the problems.

The 4 homework projects will count for 75% of the course grade, and the comprehensive final project will count for 25% of the course grade.

Assigning Course Grades:
Letter grades will be assigned according to the following tentative scale:

(a) >= 89%: grade is at least A-
(b) >= 78%: grade is at least B-
(c) >= 67%: grade is at least C-
(d) >= 56%: grade is at least D-
(e) < 56%: grade is likely F

5. Reason(s) the course is considered sufficiently rigorous and of such an advanced nature as to challenge graduate students.

The course is meant to serve as a beginning graduate course on numerical methods for differential equations, where the topics are relatively easier to understand for graduate students, including the graduate students for the newly established Postbaccalaureate Certificate in Mathematics program, who are new to computational and applied mathematics and in general do not have experience on numerical analysis and scientific computation related to differential equations. It will therefore not only prepare the students for taking more advanced applied mathematics courses, but also prepare the students who are interested in computational and applied mathematics for future research. The course will help the graduate students transfer to the field of computational and applied mathematics smoothly.

6. Academic advantages and disadvantages accruing to graduate students taking this course with undergraduates.

No particular disadvantage or advantage. The graduate students, including the graduate students for the newly established Postbaccalaureate Certificate in Mathematics program, are in general new to computational and applied Mathematics, and have the same background or the same level of knowledge of computational and applied mathematics, as the senior or junior undergraduate students who take this course.

7. The place of the course in a graduate student's program of study and why it is not considered a "remedial" undertaking intended to overcome deficiencies in the student's preparation for graduate work.

This will be a graduate level course covering theories and implementation of fundamental numerical methods for ordinary and partial differential equations. This will serve as an introductory course for new graduate students who plan to choose computational and applied mathematics as their research area. Such topics will be further discussed separately in depth in other existing graduate courses, including MATH 561 and 562 (Numerical Analysis), MATH 517 (Finite Difference Methods), and MATH 666 (Finite Element Methods). With introduction and training from this course, the new graduate students are expected to perform much better in more advanced graduate courses on applied mathematics, as well as in the qualifying exams for applied mathematics program.

8. The role of the course in an undergraduate's degree program and the academic qualifications undergraduates must have to take this course.

MATH 481 is an existing course with good enrollment. The students are mainly from areas such as engineering, statistics, etc. The topics covered in this course have been popular in their studies and research.

9. The name of the person writing the proposal.

Songting Luo

MATH 581X Numerical Methods for Differential Equations

Course Content:

- ODEs
  - Convert higher order initial value problems to first-order systems, suitable for input to standard numerical methods.
  - Solve ordinary differential equations numerically using Euler's method, Adams-Bashforth-Moulton multistep methods, and Runge-Kutta methods, as well as by using existing subroutines in Matlab.
  - Understand the concepts of accuracy, stability, and convergence, as applied to numerical ODE methods. Be able to determine the accuracy and stability of a given method.
  - Understand the importance and implementation of error estimation and stepsize control
  - Understand the concept of stiffness, and be able to solve stiff ODEs using backward differentiation formula methods, and using existing subroutines in Matlab.
  - Optional topics: shooting method for boundary value problems; multivalue implementation of multistep methods.
- Finite Difference Methods for PDEs
  - Know standard numerical differentiation formulas, and be able to use them to convert a linear PDE into a linear system of equations
  - Iterative methods for solving large sparse systems of linear equations: classical methods (Jacobi, Gauss, SOR) and modern methods (conjugate gradients)
  - Preconditioning techniques
  - Determine the stability of methods for time-dependent PDE.
  - Optional topic: multigrid methods
- Finite Element Methods for PDEs
  - Understand the concept of Galerkin methods
  - Be able to set up equations for standard finite elements on rectangular domains.
  - Optional topics: triangulation of irregular domains

Tentative Grading Policy for MATH 581X:

There will be 4 homework projects and one comprehensive final project.

The homework projects will be assigned approximately every 3 weeks according to the progress of the class. Each project will have both theoretical and programming problems. For the programming problems, the students are required to produce their own computer codes to implement the numerical methods for solving the problems.

The comprehensive final project will have two parts. One part will be an in-class exam that contains theoretical problems. The other part will be a programming project that contains programming problems. The students are required to produce their own computer codes to implement the numerical methods for solving the problems.

The 4 homework projects will count for 80% of the course grade, and the comprehensive final project will count for 20% of the course grade.

Tentative Grading Policy for MATH 481:

There will be 4 homework projects and one comprehensive final project.

The homework projects will be assigned approximately every 3 weeks according to the progress of the class. Each project will have both theoretical and programming problems. For the programming problems, the students may have access to some sample codes of the numerical methods that are needed in the problems. The students will need to study the sample codes and make necessary modifications for solving the problems.

The comprehensive final project will have two parts. One part will be an in-class exam that contains theoretical problems, with open discussions. The other part will be a programming project that contains programming problems. The students may have access to some sample codes of the numerical methods that are needed in the problems. The students will need to study the sample codes and make necessary modifications for solving the problems.

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