Program Cover Document – MAT 331: Numerical Analysis

I. Basic Course Information

Numerical Analysis focuses on developing, utilizing, and comparing methods for approximating solutions to mathematical problems. This course will particularly focus on problems arising in Calculus and Linear Algebra that cannot be solved using the techniques of those courses. In addition to execution of techniques, a theoretical understanding of algorithm error and efficiency will be established. This course has three major themes: approximating solutions to mathematical problems that cannot be solved exactly, analyzing the errors in these approximations, and understanding the computational complexity of the algorithms used . Proficiency in numerical methods requires a combinationof theory to prove properties of numerical algorithms, and calculations to implement and program algorithms.

Course prerequisites: MAT 128: Calculus B, and MAT 205: Linear Algebra.

Course description (for Bulletin): Numerical Analysis is a course which focuses on methods of approximating solutions to problems for which the techniques of the earlier Calculus courses fail. The course will cover methods of approximation, errors in approximation, and efficiency of algorithms.

II. Learning Goals

The primary goal of this course is for students to appreciate numerical analysis as a field in which there is not a concrete notion of "the right answer". Instead, students should come to understand that numerical analysis requires us to construct a reasonable approximation to a problem and to use mathematical techniques to analyze the accuracy, performance, and efficiency of that approximation.

By the end of the course students will be able to:

1. Derive, from first principles, methods for approximating solutions to problems that arise from calculus and linear algebra.
2. Understand the important subject of error that arises in scientific computing, as well as analyze methods for detecting, predicting, and controlling error.
3. Implement and execute numerical methods on a computer.
4. Utilize calculus-based and linear algebra proof techniques to study properties of numerical methods.

III. Learning Activities

Learning activities may consist of a combination of lectures, group work, written assignments, student presentations, and/or computer programming assignments. The specific choice will depend on the individual instructor. Outside of class, students are expected to do a significant amount of individual and group homework to achieve the learning goals. Students will receive detailed feedback on their assignments. The course will include multiple substantial examinations or projects, on which students will receive additional detailed feedback

IV. Student Assessment

Students will receive feedback on their work through either problem set and/or computer programming assignments, projects, or examinations.

V. List of Major Course Topics

The following list of topics will be covered in the course. Items denoted with ** are optional, *however it is expected that the instructor will choose at least two of these topics for inclusion in the course.*

1. Error Analysis and Computer Representation of Numbers
2. Roots of Nonlinear Equations
    a. Bisection Method including Error Analysis
    b. Newton's Method
    c. Secant Method **
    d. Fixed Point Methods **
3. Polynomial Interpolation
    a. Lagrange Polynomials and Error Formula
    b. Divided Differences and Newton's Interpolation
    c. Splines **
4. Numerical Differentiation and Integration
    a. Numerical Differentiation – Forward, Backward, and Center methods with Error Analysis
    b. Higher Derivatives**
    c. Trapezoidal Rule and Simpson's Rule
    d. Richardson Extrapolation and Romberg Integration **
    e. Gaussian Quadrature**
5. Numerical Linear Algebra
    a. Gaussian Elimination
    b. LU factorization and operation count
    c. Pivoting Strategies **
    d. Jacobi and Gauss-Seidel Iterative Methods
    e. Power Method
    f. Conjugate Gradient Method **

Approved 5/6/2024

Numerical Analysis **MAT 331** **Spring 2024**

Instructor: Karen Clark
Email: KCLARK@TCNJ.EDU
Office: SCP 210

The instructor reserves the right to make changes to the syllabus as needed, in keeping with the Learning Goals and Objectives for the course.

CLASS MEETING: Tuesdays and Fridays 11:00-12:20, in room SCP 229.
OFFICE HOURS: Tuesdays 9:00-10:00 & Fridays 12:30-1:30, in my office (SCP 210)

Course Description:

Numerical Analysis is a course which focuses on methods of approximating solutions to problems for which the techniques of the earlier Calculus and Linear Algebra courses fail. The course will cover methods of approximation, errors in approximation, and efficiency of algorithms.

The prerequisites are MAT 128 and MAT 205. One course unit.

The course will not include a formal meeting for the fourth hour, instead students will be using the fourth hour to work on in-depth problem sets and projects related to the course content, using computer software.

Course Materials:

The text for the course is "*Numerical Analysis",* 10th Edition, by Burden, Faires, and Burden. You may find it useful to have a scientific calculator for exams.

To enhance your learning experience and provide discounted access to the text, this course is part of an inclusive access model called First Day®. You can easily access the etextbook for this course from Canvas. TCNJ will bill you at the discounted price ($47.46) as a course charge for this course.

You have the option to opt-out of the First Day® program in Canvas. The deadline for opting out is January 30.

For more information and FAQs click here: https://customercare.bncollege.com

You may choose to use MATLAB for assignments. To download MATLAB onto your personal computer you need to go to https://software.tcnj.edu/ , log in and follow the instructions. **The download is free for TCNJ students.** You may also use Matlab online (for free) by setting up an account at https://matlab.mathworks.com/ using your TCNJ email. If you have any difficulty accessing Matlab please let me know as early in the semester as possible.

I will be using Canvas to send weekly course announcements, post homework assignments, projects, resources for exams, and course assignment deadlines. Students should be checking Canvas for updates frequently.

Course Requirements:

Students are expected to read the appropriate section in the textbook after each lecture.

Homework: I will generally assign written homework once a week, and students will have one week to complete each assignment. Often students will need to use computational tools as part of the assignment. Not all of the homework problems will be graded.

Projects: I will also generally assign one project for each chapter that we cover, which will involve more computation on your part than the homework assignments.

You may work on homework and projects in groups of two or three people if you wish. If you do work in a group, you should acknowledge whom you worked with on the top of your homework or project submission. Each member of the group should write up the assignment independently - I do not want to see assignment submissions that are identical. All work must be shown in order to receive credit. **I will assume that you will not be using any outside sources, including those available on the internet, in completing assignments. All work you turn in must be your own.** Students are responsible for making sure that any work submitted electronically is in a form that is easy for me to process (for example, each assignment should be consolidated into one pdf file). Students may submit written homework up to three days late, with a 10% penalty per day.

Suggested problems: I will post optional extra problems from your text that will not be collected. Working through these problems is a great way to solidify your understanding of course material, and to study for exams.

Exams: There will be three in-class exams. The tentative dates for these exams are:

- Friday February 16,
- Friday March 22,
- Friday April 26.

If you are ill and unable to attend the exam a makeup can be arranged only if you call my office or email me before the start of the exam, and if you get a doctor's note. Makeup exams will be more difficult than the original. Old exams with solutions are posted on Canvas for practice, but you should not expect your exam to look identical to what's there.

Final: There will be a cumulative final exam at the end of the semester. Final exams are scheduled for May 7 – May 14.

Course Purpose and Learning Goals:

The primary goal of this course is for students to appreciate numerical analysis as a field in which there is not a concrete notion of "the right answer". Instead, students should come to

understand that numerical analysis requires us to construct a reasonable approximation and to use mathematical techniques to analyze the accuracy and performance of that approximation.
By the end of the course students will be able to:
1. Derive from first principles methods for approximating the solution to problems that arise from calculus and linear algebra.
2. Understand the important subject of error that arises in scientific computing, as well as analyzing methods for detecting, predicting and controlling error.
3. Implement and execute numerical methods on a computer.
4. Utilize proof techniques from analysis and linear algebra to study properties of numerical methods.

Course Schedule:

Midterm progress reports are due on Monday March 18 and the last day to withdraw from a class is Monday March 25.
Spring break will be March 11-15.
We will not have class on Tuesday April 26 as the TCNJ Celebration of Student Achievement will be held that day.

Grading:
Projects = 10%
Homework = 10%
Exams = 50%
The lowest exam grade will count for 10% of the final grade, with the remaining two test grades counting for 20% each.
Final = 30%

Grades will be calculated as below: round as usual

Letter grade	A	A-	B+	B	B-	C+	C	C-	D+	D	F
Percentage	93-100%	90-92%	87-89%	83-86%	80-82%	77-79%	73-76%	70-72%	67-69%	63-66%	< 63%

Class Participation: I will consider class participation in computing your final grade if your grade is borderline. I encourage students to participate in class by asking and answering questions but I ask that you please raise your hand so that I can call on you.

General Policies:

COMMITMENT TO DIVERSITY, EQUITY, INCLUSION, ACCESS AND BELONGING:
The TCNJ community is composed of people with diverse backgrounds, perspectives, and experiences, and the college is committed to diversity, equity, inclusion, access and belonging.

The college's Campus Diversity Statement can be viewed here:
https://diversity.tcnj.edu/campus-diversity-statement/

CLASSROOM ENVIRONMENT AND COMMITMENT TO STUDENT SUCCESS, SAFETY AND WELL-BEING:
The TCNJ community is dedicated to the success, safety and well-being of each student. TCNJ strictly follows key policies that govern all TCNJ community members rights and responsibilities in and out of the classroom. In addition, TCNJ has established several student support offices that can provide the support and resources to help students achieve their personal and professional goals and to promote health and well-being. You can find more information about these policies and resources at the "TCNJ Student Support Resources and Classroom Policies" webpage here: https://academicaffairs.tcnj.edu/tcnj-syllabus-resources/

Students who anticipate and/or experience barriers in this course are encouraged to contact the instructor as early in the semester as possible. The Accessibility Resource Center (ARC) is available to facilitate the removal of barriers and to ensure reasonable accommodations. For more information about ARC, please visit: https://arc.tcnj.edu/

Extra Credit: I do not give extra credit assignments, so you need to make sure that you are keeping up with the classwork as it is assigned.

Email: I might periodically send messages to the class so you should get in the habit of checking your email at least daily. I will respond to email sent to me within 24 hours, and within 48 hours on weekends.

Canvas: I will post information using Canvas announcements each week. Please make sure you have changed your Canvas settings if necessary to make sure you receive announcements I post.

Weather: If there is any kind of weather event, make sure to check the college webpage and your email before heading to class. At times the college may be open but I may not be able to get to campus. In this event I will send an email to the class. I encourage students to make sure they are signed up for TCNJ Emergency Alerts: Instructions for doing so are located at https://emergency.tcnj.edu/tcnj-alerts/

Cell phones: Please make sure they are turned off during class. Texting is absolutely forbidden during class. If I observe students texting in class it will affect the final course grade.

Calculators: You may want to have a scientific calculator (one that can handle trig functions, exponentials and logs) and you may use it on homework, during class, and on exams.

ADDITIONAL INFORMATION:
If you feel like your performance in the class is being impacted by your experiences outside of class, please don't hesitate to come and talk with me. Email is a good way to reach me, and students are always able to make an appointment to speak to me.

Syllabus:
We will cover the following sections in the text:
1.2,1.3 Error analysis and Convergence
2.1-2.4 Approximating solutions of equations in one variable
3.1-3.3 Interpolation and Polynomial Approximation
4.1-4.5,4.7 Numerical Differentiation and Integration
6.1,6.2,6.5 Direct Methods for Solving Linear Systems
7.1-7.3,7.5 Iterative Techniques in Matrix Algebra
9.3 The Power Method