UNIVERSITY AT BUFFALO
Department of Civil, Structural and Environmental Engineering

CIE 411 Applied Mathematics in Civil Engineering: Numerical Methods
Spring 2019

Lecture classes:	Park Hall #440 (17-05-39), Tue/Thu 11:00am-12:20pm
Instructor: **Office hours**:	Jongmin Shim (jshim@buffalo.edu) Ketter Hall #240, Tue/Thu 09:30am-11:00am
Grader: **Office hours:**	TBD Ketter Hall #TBD, Mon/Wed TBD
Course web site:	UBLearns and Discussion Board
Recommended Classes:	EAS230 (Engineering Computations), MTH 241 (Calculus 3), MTH306 (Intro Differential Equations), MTH309 (Intro Linear Algebra); *Passing of these classes with B or higher is recommended. See instructor if questions arise.*
Text:	Numerical Methods for Engineers and Scientists (2nd ed.) by Gilat & Subramaniam, John Wiley & Sons, 2011
Software:	MATLAB can be download from the UB IT Software Website: http://www.buffalo.edu/ubit/service-guides/software/by-title/matlab.html
References:	Numerical Computing with MATLAB by Cleve Moler, https://www.mathworks.com/moler/chapters.html MATLAB Tutorial, http://www.mathworks.com/help/pdf doc/matlab/getstart.pdf MATLAB Help, http://www.mathworks.com/help/matlab/

Catalog Description:
The course introduces numerical procedures for the solution of various problems encountered in civil and environmental engineering. It emphasizes the need of numerical analysis, and demonstrates its use as a powerful problem-solving tool. The topics include MATLAB fundamentals, numerical root finding, curve fitting/interpolation, numerical differentiation/integration, and ordinary differential equations. In addition, the course briefly reviews various civil and environmental engineering problems (e.g., truss analysis, dynamics of mass-spring system, regression on traffic problems), which require numerical analysis.

Course Objectives:
The course objectives are to provide students with the fundamental basis for numerical procedures (i.e., algorithms), and to give students an opportunity to develop skills to implement algorithms in order to solve mathematical problems using MATLAB.

Course Learning Outcomes:
Upon successful completion of the course, students will be able to:

Course Learning Outcomes		Student Outcomes	Assessment Tools
I	Understand the need for numerical analysis in the solution of various problems encountered in civil and environmental engineering, and appreciate its use as a powerful problem-solving tool.	1, 3, 5, 7	HW & Project
II	Use MATLAB as a programming tool to implement numerical algorithms, and solve various numerical problems by using proper MATLAB	1, 3, 7	HW & Exam

	built-in functions.		
III	Solve system of linear equations by implementing various numerical algorithms, and estimate the condition number of a system.	1, 3, 7	HW and Exam
IV	Find approximate roots of nonlinear equations by implementing various numerical algorithms.	1, 3, 7	HW and Exam
V	Analyze data by implementing least-square method and spline interpolation.	1, 3, 6, 7	HW and Exam
VI	Numerically calculate derivatives and integration of a function.	1, 3, 7	HW and Exam
VII	Solve ordinary differential equations by implementing various numerical algorithms.	1, 3, 7	HW and Exam
VIII	Estimate numerical errors, and understand the stability of algorithm.	1	HW and Exam

Contribution of CIE 411 towards fulfillment of Student Outcomes (1)-(7):

(1) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

CIE411 is a mathematical problem solving course, which also includes numerical methods and coding centering on engineering problems. Examples used in class and problems in homework are derived from simplified engineering problems

(3) An ability to communicate effectively with a range of audiences

The clarity of implemented numerical procedures is greatly enhanced by putting sufficient comments into codes, and grading homework and exams is partly based on the appropriate usage of comments in the code. In addition, the term project presentation will be a good opportunity to improve students' presentation skill.

(5) An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

The term project will be a good opportunity to work in a collaborative environment.

(6) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

Curve fitting and interpolation are built on a student's background in data analysis.

(7) An ability to acquire and apply new knowledge as needed, using appropriate learning strategies

Throughout the class, MATLAB is used as a development environment for implementation of numerical procedures as well as a validation tool for students' codes

Relationship of Course to Student Outcomes (Course Assessment Matrix):

(1)	(2)	(3)	(4)	(5)	(6)	(7)
3		2		2	2	3

Contribution Level: Substantial = 3, Moderate = 2, and Limited = 1

Course Requirements:

There will be approximately 8 homework assignments, 1 midterm, 1 project and 1 final. While attendance is not mandatory, students should recognize that class attendance is required to do well in the course.

Office Hours and UBLearns Discussion Board:

The instructor and the TA (or grader) will be available for at least 3 hours per week. If students have subject-related questions, they should post them in the ***UBLearns Discussion Board***. For each topic, the instructor will create a forum, where students can ***share their questions*** by creating threads and either the instructor or the TA (or grader) will answer them. It is students' responsibility to frequently check the Discussion Board. ***Direct emails to the instructor are preferred only if they contain privacy.***

Reading:

All required readings will be covered in the problem sets and exams.

Homework:
It is expected that ***students will do all homework individually*** unless instructed otherwise. Specific due dates for homework will be posted on UBLearns when the homework is assigned. ***Late homework may be accepted with a penalty (e.g., 1 day late: 15% penalty, 1 week late: 30% penalty, beyond 1 week: not-accepted)*** and must be submitted directly to the instructor. Homework will not be accepted by fax or email except if approved in advance. Graded homework will be returned during the lecture period. ***If you have concerns regarding the graded homework, you should first talk to the TA (or grader) within a week before approaching the instructor. The lowest homework score will not be used in calculating the final grade***. Individual arrangements will be made with students who have documented, legitimate absences which prevent them from submitting their homework on time such as an illness requiring a doctor's visit, an automobile accident, a family emergency, jury duty, participation in a sanctioned university activity.

Project:
Students are required to complete a term project on a relevant topic in practice, and they could ***work in collaborations of 2 people***. A ***progress report*** (addressing a problem definition, approach, & expected outcome) should be submitted by March 28. The last class of the term (May 9) will be devoted to the ***project presentations*** and evaluations.

Exams:
The ***midterm exam*** (1.5 hour) will be held in regular class, but the ***final exam*** (3 hour) will be scheduled during exam week. All tests should be taken at the announced time and place. Missed exams will be assigned a grade of zero unless an acceptable excuse is provided to the instructor ***prior to the exam***. In cases of emergency, the instructor should be notified as soon as possible. Students with a legitimate absence will be given a make-up exam. ***If you have concerns regarding the graded midterm exam, you should talk to the instructor within two weeks***.

Grading Policy:
Final course grade shall be determined based on the highest score out of the followings:

- Type A

Professionalism	±5%
Homework (excluding the lowest score)	35%
Term project	10%
Midterm exam	25%
Final exam	30%

- Type B

Professionalism	±5%
Homework (excluding the lowest score)	35%
Term project	10%
Midterm exam	10%
Final exam	45%

Exact cutoffs for specific grades will depend on the level of difficulty of exams and homework assignments. These cutoffs will be determined once the final exam has been graded. However, the cutoffs will not exceed the following:

Composite score	*90*	*80*	*70*	*60*
Guaranteed grade	*A-*	*B-*	*C-*	*D*

Grade 'I' will be strictly limited to the circumstances for which the incomplete is intended; namely, satisfactory work to date and legitimate inability to complete the work within the semester. See UB policy (https://catalog.buffalo.edu/policies/explanation.html)

Academic integrity:
The University at Buffalo takes very seriously its commitment to principles of academic integrity. Please review the UB policies regarding academic integrity regularly (https://catalog.buffalo.edu/policies/integrity.html).

As an engineer, you have special ethical obligations. As per the NSPE Code of Ethics, "engineers shall avoid deceptive acts" and "shall conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession." For additional information about the procedures in place within the CSEE department, see the academic integrity section of the departmental website (http://engineering.buffalo.edu/civil-structural-environmental/undergraduate/advisement-and-policies.ethics-professionalism.html).

Accessibility Resources:
If you require classroom or testing accommodations due to a disability, please contact Accessibility Resources, located at 60 Capen Hall. Accessibility Resources can be reached by phone at (716) 645-2608 or by email at stu-accessibility@buffalo.edu. Please inform me as soon as possible about your needs so that we can coordinate your accommodations. For additional information see https://www.buffalo.edu/studentlife/who-we-are/departments/accessibility.html.

Classroom Professionalism:
To provide an environment that is professional and conducive to learning, it is important that all students observe the following classroom etiquette (modified from https://catalog.buffalo.edu/policies/obstruction.html)

In Class

- Come to class on time. If you must enter a class late, do so quietly.
- Turn off cell phones.
- Focus on class material during class time.
- Try not to talk with other classmates while the instructor or another student is peaking.
- Try not to leave class until the instructor has dismissed class.
- **Do not open web browsers or email servers while laptops are used in class.**

Outside the Classroom

- Students are expected to use professional style in all communications, including email, with course faculty and teaching assistants.
- This includes the use of salutations and closings (including clear identification of the author) and correct grammar.

***Tentative* Course Schedule:**

No.	Date	Topic	Gilat's 2nd	Due
		1. MATLAB (2.5 weeks)		
1	01/29	MATLAB Basics I	App. A	
2	01/31	MATLAB Basics II		
3	02/05	MATLAB Basics III		
4	02/07	MATLAB Basics IV		
5	02/12	MATLAB Basics V		
		2. Introduction (0.5 weeks)		
6	02/14	Binary number & numerical errors	1.1-4	
		3. Linear Equations (2 weeks)		
7	02/19	System of linear equations & norms/condition number.	2, 4.10	
8	02/21	Gauss(-Jordan) elimination	4.1-6	PSet #1
9	02/26	Jacobi/Gauss-Seidel iterative methods & Ill-conditioned systems	4.7, 4.11	
10	03/28	MATLAB functions (\, inv, norm, cond)	4.8	PSet #2
		4. Nonlinear Equations (2 weeks)		
11	03/05	Calculus of multivariable functions	2	

12	03/07	Bisection/Newton/secant methods	3.1-6	
13	03/12	System of nonlinear equations	3.10	PSet #3
14	03/14	MATLAB functions (fzero, fsolve)	3.8-9	
	03/19	*Spring Break*		
	03/21	*Spring Break*		
		5. Curve Fitting & Interpolation (1.5 week)		
15	03/26	Minimum principle in quadratic form & Lagrange polynomials	2	
16	03/28	Least-square regression, Lagrange polynomial/spline interpolation	5.1-4, 5.6, 5.8	Progress Report
17	04/02	MATLAB functions (polyfit, interp1, largrangepoly)	5.7	PSet #4
(1)	**04/04**	**MID-TERM EXAM** **Parker Hall #440, 11:00am-12:20pm**		
		6. Numerical Differentiation (1 week)		
18	04/09	Taylor series expansion & mean value theorem for derivatives	2	
19	04/11	Finite difference approximations, MATLAB functions (diff)	6.1-4, 6.7, 6.9-10	PSet #5
		7. Numerical Integration (1 week)		
20	04/16	Integral of functions	2	
21	04/18	Newton-Cotes methods & Gauss quadrature, MATLAB function (trapz, integral)	7.1-5, 7.7-8	PSet #6
		8. Ordinary Differential Equations (2.5 weeks)		
22	04/23	Ordinary differential equations	2, 8.9	
23	04/25	Single-step explicit methods	8.2-5	PSet #7
24	04/30	Single-step implicit/mixed methods	8.2, 8.7	
25	05/02	Higher-order IVPs & accuracy/stability	8.8-9	
26	05/07	Shooting/finite difference methods for BVPs, MATLAB functions (ode45, bvp4c)	8.10-14, 9.3-5	
(2)	**05/09**	**STUDENT PRESENTATIONS (Part II)** **Parker Hall #440, 11:00am-12:20pm**		PSet #8
	05/14	**FINAL EXAM** **Parker Hall #440, 11:45am-02:45pm**		