Matrix and Numerical Methods in Systems Engineering

ESI3327C

Class Periods: MWF, Period 7 (1:55 PM – 2:45 PM)
Location: TUR L005

Instructor:

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Graders:

Name: Brandon Mancilla
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Location: Weil 405B and Zoom

Name: Nicholas Conte
Email Address: nicholas.conte@ufl.edu
Office Hours: Tuesdays and Thursdays 10–11 AM
Location: Weil 405B

Course Description
Theory and application of vector, matrix and other numerical methods to systems problems. Simultaneous linear equations, characteristic values, quadratic forms, error analysis, use of series, nonlinear equations, interpolation, and optimization. The laboratory sessions will emphasize on obtaining numerical solutions using MATLAB.

Course Pre-Requisites / Co-Requisites
MAC 2313 and MAS 3114 with minimum grades of C.

Course Objectives
• To understand the underlying fundamental ideas behind numerical methods and the concepts behind the techniques presented in the course.
• To grasp the analysis of algorithms, computational complexity, and other concepts and modern developments in numerical methods.
• To develop facility with the techniques themselves, and to be able to solve small size problems analytically.
• To learn how to implement the methods in the MATLAB programming environment.

Relation to Program Outcomes (ABET):

Outcome	Coverage*
1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	High
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	
3. An ability to communicate effectively with a range of audiences	

4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	
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	
6. An ability to develop and conduct appropriate experimentation, analyze, and interpret data, and use engineering judgment to draw conclusions	
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies	Medium

*Coverage is given as high, medium, or low. An empty box indicates that this outcome is not covered or assessed in the course.

Recommended Textbooks

- Title: Numerical Methods and Optimization: An Introduction
  Authors: S. Butenko and P. Pardalos
  Publisher: Chapman and Hall, 1st edition

Course Modules:

- Module 1: Linear Algebra Review
  - Vectors & Vector Spaces
  - Matrix Properties and Norms
  - Eigenvalues and Eigenvectors
- Module 2: Computer Number System, Floating Point Arithmetic, & Errors
  - Computer Number Systems
  - Conversion from one base to another (binary, octal, decimal, hexadecimal…)
  - Normalized Floating Point Systems and IEEE Single & Double Precision Floating Point Systems
  - Floating-point operations
  - Rounding errors and cardinality
- Module 3: Direct and Iterative Methods for Linear Systems
  - Computer Storage and Data Structures for Matrices
  - Backward Substitution and Naïve Gauss Reduction
  - Partial and Scaled Partial pivoting
  - LU decomposition: Determinant and Inverse of A
  - Iterative Methods for Linear Systems
- Module 4: Iterative Methods for Nonlinear Equations (Root Finding Methods)
  - The Bisection method
  - Newton's method
  - The Secant method
- Module 5: Polynomial Interpolation and Splines Fitting
  - Lagrange Polynomial Interpolation
  - Newton's Polynomials and Divided Differences
  - Errors in Polynomial Interpolation and Linear Spline Interpolation
  - Quadratic and Cubic Splines Fitting
- Module 6: Numerical Differentiation & Integration
  - Forward, Backward and Central difference formulae
  - Richardson Extrapolation
  - Midpoint, Trapezoidal & Simpson's Rules
  - Romberg formulae

Course Schedule (Tentative)

Week	***Date***	***Lecture Topic***	***HW Due***	***Module***
1	Friday, August 22	Introduction, Syllabus, and Icebreaker		1
2	Monday, August 25	Applications in Systems Engineering, Vectors & Vector Spaces		
	Wednesday, August 27	Vectors & Vector Spaces		
	Friday, August 29	Matrix Properties and Norms		
3	Monday, September 1	**Labor Day (No Classes)**		
	Wednesday, September 3	Eigenvalues and Eigenvectors		
	Friday, September 5	Lab 1: Matrix Operations		
4	Monday, September 8	Case Study: Applications in Systems Engineering	HW 1	
	Wednesday, September 10	Computer Number Systems and Base Conversion		2
	Friday, September 12	Base Conversions & Normalized Floating Point Systems		
5	Monday, September 15	IEEE Single & Double Precision Floating Point Systems		
	Wednesday, September 17	Rounding Errors, Floating Point Operations, and Cardinality		
	Friday, September 19	Lab 2: Conversions, Rounding, and Errors		
6	Monday, September 22	Case Study: Applications in Systems Engineering	HW 2	
	Wednesday, September 24	Back Substitution and Gauss Reduction		3
	Friday, September 26	Naive Gauss Elimination and Pivoting Strategies		
7	Monday, September 29	Unscaled (Simple) and Scaled Partial Pivoting		
	Wednesday, October 1	LU Decomposition		
	Friday, October 3	Iterative Methods for Linear Systems		
8	Monday, October 6	Lab 3: Linear Systems		
	Wednesday, October 8	Case Study: Applications in Systems Engineering	HW 3	
	Friday, October 10	Root Finding Methods: The Bisection Method		4
9	Monday, October 13	Root Finding Methods: Newton's Method		
	Wednesday, October 15	Root Finding Methods: The Secant Method		
	Friday, October 17	**Homecoming Day (No Classes)**		
10	Monday, October 20	Midterm Exam Review		
	Wednesday, October 22	**Midterm Exam**		
	Friday, October 24	Midterm Solving		
11	Monday, October 27	Lab 4: Root Finding Methods		
	Wednesday, October 29	Case Study: Applications in Systems Engineering	HW 4	
	Friday, October 31	Lagrange Polynomial Interpolation		5
12	Monday, November 3	Newton's Polynomials and Divided Differences		
	Wednesday, November 5	Errors in Polynomial Interpolation + Linear Spline Interpolation		
	Friday, November 7	Quadratic and Cubic Splines Fitting		
13	Monday, November 10	Lab 5: Polynomial Interpolation and Splines Fitting		
	Wednesday, November 12	Case Study: Applications in Systems Engineering	HW 5	
	Friday, November 14	Richardson Extrapolation		6
14	Monday, November 17	Midpoint, Trapezoidal & Simpson's Rules		
	Wednesday, November 19	Romberg formulae		
	Friday, November 21	Lab 6: Numerical Differentiation & Integration		
15	Monday, November 24	**Thanksgiving Break**		
	Wednesday, November 26			
	Friday, November 28			
16	Monday, December 1	Case Study: Applications in Systems Engineering	HW 6	
	Wednesday, December 3	Final Exam Review		
	December 4 & 5	Reading Days		
17	Friday, December 12	**Final Exam (10:00 AM – 12:00 PM)**		

Grading Scheme – How will I demonstrate my knowledge and be assessed?

Assessment	Base Weights	Oops! I did poorly on the midterm	I froze up on the final	I struggled along the way but nailed the final
Case Studies	10%	10%	10%	10%
Homework Sets	15%	15%	15%	10%
Midterm Exam	35%	30%	40%	30%
Final Exam	40%	45%	35%	50%

Grading Policy

Percent	Grade	Grade Points
93.4 - 100	A	4.00
90.0 - 93.3	A-	3.67
86.7 - 89.9	B+	3.33
83.4 - 86.6	B	3.00
80.0 - 83.3	B-	2.67
76.7 - 79.9	C+	2.33
73.4 - 76.6	C	2.00
70.0 - 73.3	C-	1.67
66.7 - 69.9	D+	1.33
63.4 - 66.6	D	1.00
60.0 - 63.3	D-	0.67
0 - 59.9	E	0.00

- A C- will not be a qualifying grade for critical tracking courses.

Policies we hope never affect you!

- Please note that the midterm exam date will be scheduled at the beginning of the semester and announced in advance. This will give you time to make arrangements. Students are expected to prioritize this date.
- If health, disabilities, or family emergencies prevent you from turning in work on time, talk to me as soon as you can! Barring such circumstances, no credit will be assigned to assignments submitted after the deadline.
- We hold the Honor Code in high esteem! If you are caught cheating, your work will receive a zero and you will receive a failing grade in the course. This is separate from any pursuit of an Honor charge.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values varied perspectives within our community and is committed to supporting the University's core values, including the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of race, creed, color, religion, age, disability, sex, sexual orientation, gender identity and expression, marital status, national origin, political opinions or affiliations, genetic information, and veteran status.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact Dr. Atweh or any of the following:

• Your academic advisor or Undergraduate Coordinator
• HWCOE Human Resources, 352-392-0904, student-support-hr@eng.ufl.edu
• Pam Dickrell, Associate Dean of Student Affairs, 352-392-2177, pld@ufl.edu

University Academic Policies & Campus Resources

For official academic policies and student support resources, please refer to the University of Florida's syllabus policies: https://go.ufl.edu/syllabuspolicies. This includes information on attendance, grading, academic integrity, accommodations for students with disabilities, course evaluations, in-class recording policies, library services, and other valuable campus support.