NATIONAL UNIVERSITY OF SAN MARCOS

FACULTY OF MATHEMATICAL SCIENCES

SYLLABUS

1. GENERAL INFORMATION

1.1 Course name	:	Numerical Analysis IV
1.2 Code	:	MA327
1.3 Academic Program	:	Scientific Computing
1.4 Credits	:	5
1.5 Prerrequisites	:	• MA326. Numerical Analysis III. (7^{th} Sem) • MA213. Partial Differential Equations. (7^{th} Sem)
1.6 Type of Course	:	Elective
1.7 Area of Studies	:	Estudios Generales
1.8 Number of Weeks	:	16
1.9 Hours per week	:	4 HT; 2 HP;
1.10 Cycle	:	I
1.11 Learning modality	:	Face to face
1.12 Academic Period	:	2026-I
1.13 Semester Start Date	:	
1.14 Semester End Date	:	

2. PROFESSORS

Meetings after coordination with the professor

3. INTRODUCTION TO THE COURSE

Numerical Analysis 4 provides the computational tools necessary to solve Partial Differential Equations (PDEs), which describe a wide range of phenomena in physics, engineering, and finance. The course focuses on the three fundamental types of second-order PDEs: elliptic, parabolic, and hyperbolic. Students will learn to discretize continuous domains, analyze the stability and convergence of numerical schemes, and implement algorithms for complex boundary value problems.

4. GOALS

- Classify partial differential equations and understand their physical implications.
- Develop and implement Finite Difference Methods (FDM) for different PDE types.
- Analyze the stability (Von Neumann), consistency, and convergence of numerical schemes.
- Introduce advanced discretization techniques such as Finite Element and Finite Volume methods.

5. COMPETENCES

ABET-1) An ability to identify, formulate, and solve broadly defined technical or scientific problems by applying knowledge of mathematics and science and/or technical topics to areas relevant to the discipline. (Usage)

ABET-3) An ability to develop and conduct experiments or test hypotheses, analyze and interpret data, and use scientific judgment to draw conclusions. (Usage)

6. TOPICS

Unit 1: Elliptic Equations and Boundary Value Problems (20 hours)	
Competences Expected: ABET-1,ABET-3	
Topics	**Learning Outcomes**
• Classification of second-order PDEs • Finite Difference Method for Laplace and Poisson equations • Boundary conditions: Dirichlet, Neumann, and Robin • Iterative solvers for large sparse systems (Jacobi, Gauss-Seidel, SOR) • Introduction to Finite Element Method (FEM) in 1D	• Discretize steady-state problems using five-point stencils [Usage] • Solve resulting linear systems using optimized iterative methods [Assessment] • Evaluate the effect of grid refinement on the solution accuracy [Familiarity]
Readings : [**Burden2016**], [**Quarteroni2007**]	

Unit 2: Parabolic Equations and Evolution Problems (20 hours)	
Competences Expected: ABET-1,ABET-3	
Topics	**Learning Outcomes**
• The Heat Equation in 1D and 2D • Explicit schemes and stability restrictions (CFL condition) • Implicit schemes: Crank-Nicolson and Backward Euler • Consistency and Von Neumann stability analysis	• Implement time-stepping algorithms for diffusion processes [Usage] • Determine the stability limits of explicit numerical schemes [Assessment] • Apply the Thomas algorithm for tridiagonal systems in implicit methods [Usage]
Readings : [**Heath2002**], [**Quarteroni2007**]	

Unit 3: Hyperbolic Equations and Wave Phenomena (20 hours)	
Competences Expected: ABET-1,ABET-3	
Topics	**Learning Outcomes**
• First-order advection equations • The Wave Equation and D'Alembert's solution • Upwind, Lax-Wendroff, and Leapfrog schemes • Dispersion and dissipation errors in wave propagation	• Design numerical schemes for transport and wave equations [Usage] • Analyze numerical diffusion and oscillation in high-order schemes [Assessment] • Verify the Courant-Friedrichs-Lewy (CFL) condition for hyperbolic systems [Usage]
Readings : [**LeVeque2007**], [**Heath2002**]	

Unit 4: Advanced Topics in Numerical PDEs (20 hours)	
Competences Expected: ABET-1,ABET-3	
Topics	**Learning Outcomes**
• Non-linear PDEs and Burgers' equation • Introduction to Finite Volume Method (FVM) for conservation laws • Multidimensional problems and Alternating Direction Implicit (ADI) methods • Computational implementation using Python/MATLAB	• Implement numerical solvers for non-linear conservation laws [Usage] • Generalize 1D methods to complex 2D/3D geometries [Familiarity] • Perform comparative studies of different discretization techniques [Assessment]
Readings : [**Quarteroni2007**], [**LeVeque2007**]	

7. WORKPLAN

7.1 Methodology

Individual and team participation is encouraged to present their ideas, motivating them with additional points in the different stages of the course evaluation.

7.2 Theory Sessions

The theory sessions are held in master classes with activities including active learning and roleplay to allow students to internalize the concepts.

7.3 Practical Sessions

The practical sessions are held in class where a series of exercises and/or practical concepts are developed through problem solving, problem solving, specific exercises and/or in application contexts.

8. EVALUATION SYSTEM

********* EVALUATION MISSING ********

9. BASIC BIBLIOGRAPHY