NATIONAL UNIVERSITY OF SAN MARCOS

FACULTY OF MATHEMATICAL SCIENCES

SYLLABUS

1. GENERAL INFORMATION

1.1 Course name	:	Numerical Analysis II
1.2 Code	:	MA325
1.3 Academic Program	:	Scientific Computing
1.4 Credits	:	4
1.5 Prerrequisites	:	MA221. Numerical Analysis I. (5^{th} Sem)
1.6 Type of Course	:	Mandatory
1.7 Area of Studies	:	Estudios Generales
1.8 Number of Weeks	:	16
1.9 Hours per week	:	2 HT; 4 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

This course advances the study of numerical methods for advanced mathematical problems, focusing on differential equations, numerical integration, and eigenvalue problems. It develops skills for implementing and analyzing sophisticated numerical algorithms with applications in engineering and computational sciences, with emphasis on stability and computational efficiency.

4. GOALS

- Solve ordinary and partial differential equations numerically
- Apply advanced numerical integration and differentiation methods
- Analyze eigenvalue problems and matrix decompositions
- Evaluate stability and convergence of advanced numerical 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-2) An ability to formulate or design a system, process, procedure, or program for the intended purpose. (Usage)

6. TOPICS

Unit 1: Numerical Methods for Ordinary Differential Equations (ODEs) (20 hours)	
Competences Expected: ABET-1,ABET-2	
Topics	**Learning Outcomes**
• Euler's method and its variants (forward, backward) • Runge-Kutta methods • Multistep methods (Adams-Bashforth, Adams-Moulton) • Stability and convergence analysis for ODE solvers • Systems of ODEs and higher-order ODEs	• Implement basic ODE solvers (Euler, Runge-Kutta) [Usage] • Analyze the stability and convergence properties of ODE numerical methods [Assessment] • Select an appropriate numerical method for a given ODE based on stability and accuracy requirements [Assessment] • Solve systems of ODEs and convert higher-order ODEs to first-order systems [Usage]
Readings : [**Burden2016**], [**Chapra2015**]	

Unit 2: Numerical Differentiation and Integration (20 hours)	
Competences Expected: ABET-1,ABET-2	
Topics	**Learning Outcomes**
• Finite difference approximations (forward, backward, central) • Richardson extrapolation • Newton-Cotes formulas (Trapezoidal rule, Simpson's rule) • Gaussian quadrature • Error analysis for numerical integration	• Compute derivatives of functions using finite difference schemes [Usage] • Apply Richardson extrapolation to improve the accuracy of numerical approximations [Usage] • Implement numerical integration rules (Trapezoidal, Simpson, Gaussian) [Usage] • Compare the accuracy and efficiency of different numerical integration methods [Assessment] • Analyze the error for numerical differentiation and integration formulas [Assessment]
Readings : [**Burden2016**], [**Chapra2015**]	

Unit 3: Numerical Linear Algebra (20 hours)	
Competences Expected: ABET-1,ABET-2	
Topics	**Learning Outcomes**
• LU decomposition and its applications • QR decomposition and least squares problems • Singular Value Decomposition (SVD) and its applications • Condition number and numerical stability of linear systems • Iterative methods for linear systems (Jacobi, Gauss-Seidel, Conjugate Gradient)	• Implement LU and QR decomposition algorithms for solving linear systems [Usage] • Explain the geometric and algebraic meaning of the Singular Value Decomposition [Familiarity] • Use SVD for applications such as matrix approximation and principal component analysis [Usage] • Analyze the stability of a linear system using its condition number [Assessment] • Select and implement an appropriate iterative method for solving large, sparse linear systems [Assessment]
Readings : [**Burden2016**], [**Chapra2015**]	

Unit 4: Interpolation and Function Approximation (20 hours)	
Competences Expected: ABET-1,ABET-2	
Topics	**Learning Outcomes**
• Polynomial interpolation (Lagrange, Newton forms) • Spline interpolation (cubic splines) • Least squares approximation • Runge's phenomenon and Chebyshev nodes • Error analysis for interpolation	• Construct interpolating polynomials using different methods [Usage] • Implement cubic spline interpolation [Usage] • Apply least squares method for data fitting [Usage] • Explain Runge's phenomenon and strategies to mitigate it [Familiarity] • Analyze the error of an interpolation scheme [Assessment]
Readings : [**Burden2016**], [**Chapra2015**]	

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