NATIONAL UNIVERSITY OF SAN MARCOS

FACULTY OF MATHEMATICAL SCIENCES

SYLLABUS

1. GENERAL INFORMATION

1.1 Course name	:	Numerical Analysis III
1.2 Code	:	MA326
1.3 Academic Program	:	Scientific Computing
1.4 Credits	:	4
1.5 Prerrequisites	:	MA325. Numerical Analysis II. (6^{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

Numerical Analysis 3 focuses on the computational solution of Ordinary Differential Equations (ODEs). In computational mathematics, many systems cannot be solved analytically; therefore, understanding the convergence, stability, and efficiency of numerical integrators is vital. This course covers from basic one-step methods to advanced Runge-Kutta schemes and the specialized treatment of stiff equations, which are critical in simulating chemical reactions, electrical circuits, and structural mechanics.

4. GOALS

- Understand the fundamental theory of numerical methods for Initial Value Problems (IVPs).
- Master the construction and analysis of high-order Runge-Kutta methods.
- Evaluate the stability and convergence of numerical schemes.
- Implement specialized algorithms for Stiff Differential Equations.

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: Numerical Solution of ODEs: Foundations (20 hours)	
Competences Expected: ABET-1,ABET-3	
Topics	**Learning Outcomes**
• Review of Existence and Uniqueness (Lipschitz continuity) • Elementary methods: Euler, Heun, and Taylor series methods • Error analysis: Local truncation error and Global error • Consistency, Convergence, and Zero-stability	• Formulate discrete approximations for continuous differential systems [Usage] • Derive the local truncation error for basic one-step methods [Assessment] • Analyze the impact of step size on numerical stability [Familiarity]
Readings : [**Burden2016**], [**Heath2002**]	

Unit 2: Runge-Kutta Methods (20 hours)	
Competences Expected: ABET-1,ABET-3	
Topics	**Learning Outcomes**
• General structure of Runge-Kutta (RK) methods • Butcher Tableaus and order conditions • Explicit and Implicit Runge-Kutta methods • Adaptive step-size control: Runge-Kutta-Fehlberg (RK45)	• Construct high-order RK methods using Butcher Tableaus [Usage] • Implement adaptive algorithms to optimize computational cost [Assessment] • Prove the order of convergence for specific RK schemes [Familiarity]
Readings : [**Quarteroni2007**], [**Butcher2016**]	

Unit 3: Linear Multi-step Methods (20 hours)	
Competences Expected: ABET-1,ABET-3	
Topics	**Learning Outcomes**
• Adams-Bashforth and Adams-Moulton formulas • Predictor-Corrector methods • General Theory of Linear Multi-step methods (Dahlquist theorems) • Comparison between RK and Multi-step methods	• Develop multi-step codes for efficient long-term integration [Usage] • Verify the root condition for zero-stability [Assessment] • Select appropriate methods based on the trade-off between memory and accuracy [Familiarity]
Readings : [**Burden2016**], [**Quarteroni2007**]	

Unit 4: Stiff Equations and Absolute Stability (20 hours)	
Competences Expected: ABET-1,ABET-3	
Topics	**Learning Outcomes**
• Definition and characterization of Stiff Systems • Linear Stability Analysis: The test equation and Stability Regions • A-stability and L-stability • Backward Differentiation Formulas (BDF) and Implicit methods for stiffness	• Identify stiffness in physical systems through eigenvalue analysis [Assessment] • Plot and interpret stability regions in the complex plane [Usage] • Apply implicit solvers to overcome step-size restrictions in stiff problems [Assessment]
Readings : [**Heath2002**], [**Butcher2016**]	

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