National University of Engineering (UNI)
School of Computer Science
Syllabus 2027-I

1. COURSE

MA213. Differential Equations (Mandatory)

2. GENERAL INFORMATION

2.1 Course	:	MA213. Differential Equations
2.2 Cycle	:	4^{th} Cycle.
2.3 Credits	:	4
2.4 Hours	:	2 HT; 4 HP;
2.5 Duration of the period	:	16 weeks
2.6 Type of course	:	Mandatory
2.7 Learning modality	:	Face to face
2.8 Prerrequisites	:	BMA103. Integral Calculus. (2^{nd} Sem)

3. PROFESSORS

Meetings after coordination with the professor

4. INTRODUCTION TO THE COURSE

Differential Equations provides the mathematical tools to model systems that evolve continuously, both in a single variable (ordinary differential equations) and in several variables (partial differential equations). The course covers analytical solution methods for first-order and higher-order ODEs, the Laplace transform, an introduction to the classification and solution of PDEs (heat, wave, and Laplace equations), and the numerical methods used to approximate solutions when an analytical one is not available. It is fundamental preparation for later courses in computational physics, scientific computing, and engineering modeling.

5. GOALS

- Solve first-order and higher-order ordinary differential equations using analytical methods, including the Laplace transform.
- Classify partial differential equations and solve initial-boundary value problems using separation of variables and Fourier series.
- Implement numerical methods (Runge-Kutta, finite differences) for approximating solutions of ODEs and PDEs.

6. COMPETENCES

AG-C07) Computing Knowledge: Applies knowledge of mathematics, science, and computing. (Usage)

7. TOPICS

Unit 1: First-Order Ordinary Differential Equations (18 hours)	
Competences Expected: AG-C07	
Topics	**Learning Outcomes**
• First-order ODEs: separable, linear, exact equations, and integrating factors	• Classify ODEs by order, linearity, and type, and select an appropriate solution method [Familiarity]
Readings : [BDM17], [Zil18]	

Unit 2: Higher-Order Differential Equations and Systems (30 hours)	
Competences Expected: AG-C07	
Topics	**Learning Outcomes**
• Higher-order linear ODEs: characteristic equations, variation of parameters, and undetermined coefficients • Systems of linear ODEs: matrix exponential, eigenvalue methods, and phase portraits • Existence and uniqueness theorems (Picard-Lindelöf) and continuation of solutions • Laplace transform methods for solving ODEs with discontinuous forcing	• Solve linear systems of ODEs using eigenvalue methods and sketch their phase portraits [Usage] • Apply the Laplace transform to solve ODEs with piecewise and impulsive forcing functions [Assessment]
Readings : [BDM17], [Zil18], [NSS17]	

Unit 3: Partial Differential Equations (26 hours)	
Competences Expected: AG-C07	
Topics	**Learning Outcomes**
• Classification of second-order linear PDEs: elliptic, parabolic, and hyperbolic • Fourier series and separation of variables for the heat and wave equations • Green's functions for the Laplace and Poisson equations • Method of characteristics for first-order and hyperbolic PDEs; shock formation • Weak solutions, Sobolev spaces, and variational formulations of elliptic problems	• Classify a second-order PDE and identify the appropriate solution strategy [Familiarity] • Apply separation of variables and Fourier series to solve initial-boundary value problems [Usage] • Derive weak formulations of elliptic PDEs and prove existence of solutions using the Lax-Milgram theorem [Assessment]
Readings : [Hab13]	

Unit 4: Numerical Methods for Differential Equations (26 hours)	
Competences Expected: AG-C07	
Topics	**Learning Outcomes**
• Runge-Kutta methods: Euler, RK4, and embedded methods for error control • Linear multistep methods: Adams-Bashforth, Adams-Moulton, and BDF methods • Stability analysis: zero-stability, absolute stability regions, and stiff ODEs • Finite difference methods for parabolic and elliptic PDEs: stability and convergence	• Compare explicit and implicit ODE solvers and explain their relative stability for stiff problems [Familiarity] • Implement a Runge-Kutta method with adaptive step control and apply it to a system of ODEs [Usage] • Analyze the stability and convergence of a finite difference scheme for a parabolic PDE [Assessment]
Readings : [BF10], [Hab13]	

8. WORKPLAN

8.1 Methodology

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

8.2 Theory Sessions

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

8.3 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.

9. EVALUATION SYSTEM

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

Lab Sessions:
In order to verify their competences, several activities including active learning and roleplay will be developed during lab sessions.

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

Reading:
Throughout the course different readings are provided, which are evaluated. The average of the notes in the readings is considered as the mark of a qualified practice. The use of our virtual campus allows each student to access the course information, and interact outside the classroom with the teacher and with the other students.

The final grade NF depends on the following grades:

- PE: Partial Exam.
- FE: Final Exam.
- P: Permanent Evaluation (Average of practical work and graded assignments).

The final grade NF is calculated as follows:

$$NF = \frac{PE + FE + P}{3}$$

10. BASIC BIBLIOGRAPHY

[BF10] Richard L. Burden and J. Douglas Faires. *Numerical Analysis*. 9th. Cengage Learning, 2010.

[Hab13] Richard Haberman. *Applied Partial Differential Equations with Fourier Series and Boundary Value Problems*. 5th. Pearson, 2013.

[BDM17] William E. Boyce, Richard C. DiPrima, and Douglas B. Meade. *Ecuaciones Diferenciales y Problemas con Valores en la Frontera*. 11th. Limusa Wiley, 2017.

[NSS17] R. Kent Nagle, Edward B. Saff, and Arthur David Snider. *Fundamentals of Differential Equations*. 9th. Pearson, 2017.

[Zil18] Dennis G. Zill. *Ecuaciones Diferenciales con Aplicaciones de Modelado*. 11th. Cengage Learning, 2018.