



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

1. COURSE

BMA104. Advanced Differential and Integral Calculus (Mandatory)

2. GENERAL INFORMATION

2.1 Course	: BMA104. Advanced Differential and Integral Calculus
2.2 Semester	: 3 rd Semester.
2.3 Credits	: 5
2.4 Hours	: 4 HT; 2 HP;
2.5 Duration of the period	: 16 weeks
2.6 Type of course	: Mandatory
2.7 Learning modality	: Face to face
2.8 Prerequisites	: BMA102. Differential Calculus. (1 st Sem)

3. PROFESSORS

Meetings after coordination with the professor

4. INTRODUCTION TO THE COURSE

Advanced differential and integral calculus provides the rigorous foundations for understanding multidimensional phenomena in engineering and computer science. This course covers vector functions, multivariable calculus, differentiable transformations, multiple integrals, and integral calculus on manifolds, including the fundamental theorems of Green, Stokes, and Gauss. These tools are essential for modeling complex systems, optimizing multivariable functions, and solving problems in computer graphics, computer vision, and physical simulations.

5. GOALS

- Study vector functions of a real variable and the differential geometry of space curves.
- Apply differential calculus to functions of several variables: partial derivatives, gradient, tangent plane, optimization, and Taylor's theorem.
- Analyze differentiable transformations between vector spaces using the Jacobian matrix and the inverse and implicit function theorems.
- Evaluate multiple integrals in different coordinate systems and compute areas, volumes, and centers of mass.
- Compute line integrals and apply Green's Theorem and the concept of conservative fields.
- Compute surface integrals and apply Stokes' Theorem and the Divergence Theorem.

6. COMPETENCES

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

7. TOPICS

Unit 1: Vector Functions of a Real Variable (14 hours)	
Competences Expected: AG-C07	
Topics	Learning Outcomes
• Definition, domain, and range of vector functions of a real variable • Limits, continuity, and derivatives of vector functions • Arc length and natural parametrization of a curve • Tangent, normal, and binormal vectors; moving Frenet frame • Curvature, torsion, and Frenet-Serret formulas	• Identify limits, continuity, and derivatives of vector functions of a real variable [Familiarity] • Compute tangent, normal, and binormal vectors and reparametrize a curve by arc length [Usage] • Calculate curvature and torsion using the Frenet-Serret formulas [Assessment]
Readings : [Apostol1997], [MarsdenTromba2011]	

Unit 2: Multivariable Differential Calculus (18 hours)	
Competences Expected: AG-C07	
Topics	Learning Outcomes
• Limits and continuity of functions of several variables in $\mathbb{R}^n$ • Partial derivatives, directional derivatives, and the gradient vector • Tangent plane, total differential, and linear approximation • Extrema of multivariable functions and Lagrange multipliers • Taylor's theorem for functions of several variables	• Evaluate limits and determine continuity of functions of several variables [Familiarity] • Compute gradients, directional derivatives, and tangent planes for multivariable functions [Usage] • Apply Lagrange multipliers to solve constrained optimization problems in computing and data science [Usage] • Expand functions of several variables using Taylor's theorem and estimate error bounds [Assessment]
Readings : [Apostol1997], [MarsdenTromba2011]	

Unit 3: Multivariable Transformations (12 hours)	
Competences Expected: AG-C07	
Topics	Learning Outcomes
• Transformations from $\mathbb{R}^n$ to $\mathbb{R}^m$ and their differentiability • Jacobian matrix and Jacobian determinant • Change of variables in polar, cylindrical, and spherical coordinates • Inverse function theorem • Implicit function theorem in multivariable contexts	• Describe transformations between coordinate systems using the Jacobian matrix [Familiarity] • Compute the Jacobian and apply change of variables to evaluate multiple integrals [Usage] • Apply the inverse and implicit function theorems to analyze local invertibility [Assessment]
Readings : [Apostol1997], [MarsdenTromba2011]	

Unit 4: Multiple Integrals (18 hours)	
Competences Expected: AG-C07	
Topics	Learning Outcomes
• Double integrals over rectangles and general regions; iterated integrals (Fubini's theorem) • Double integrals in polar coordinates and change-of-variables formula • Triple integrals in Cartesian coordinates and applications to volume and mass • Triple integrals in cylindrical and spherical coordinates • Applications: area, volume, centers of mass, and moments of inertia	• Evaluate double and triple integrals over general regions using iterated integrals [Usage] • Apply coordinate changes in polar, cylindrical, and spherical systems to simplify multiple integrals [Usage] • Compute areas, volumes, and centers of mass using multiple integrals [Assessment]
Readings : [Apostol1997], [MarsdenTromba2011]	

Unit 5: Line Integrals and Vector Fields (10 hours)	
Competences Expected: AG-C07	
Topics	Learning Outcomes
• Vector fields: definition, visualization, divergence, and curl • Line integrals of scalar functions: arc length and mass • Line integrals of vector fields: work and circulation • Conservative fields, potential functions, and path independence • Green's Theorem and its applications in the plane	• Compute scalar and vector line integrals over oriented curves [Usage] • Determine whether a vector field is conservative and construct its potential function [Usage] • Apply Green's Theorem to evaluate line integrals via double integrals [Assessment]
Readings : [Apostol1997], [MarsdenTromba2011]	

Unit 6: Surface Integrals and Fundamental Theorems (12 hours)	
Competences Expected: AG-C07	
Topics	Learning Outcomes
• Parametric surfaces, tangent plane, and surface area • Surface integrals of scalar functions • Flux integrals: surface integrals of vector fields • Stokes' Theorem: relation between line integrals and surface integrals • Divergence Theorem (Gauss): relation between flux and volume integral	• Parametrize surfaces and evaluate scalar and flux surface integrals [Usage] • Apply Stokes' and Divergence Theorems to reduce complex integrals [Assessment] • Relate local differential properties (curl, divergence) to global behavior via integral theorems [Assessment]
Readings : [Apostol1997], [MarsdenTromba2011]	

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