Differential Calculus

1. **Course number and name:** 020CDFNI4 Differential Calculus

2. **Credits and contact hours:** 6 ECTS credits, 3x1:15 contact hours

3. **Name(s) of instructor(s) or course coordinator(s):** Georges Chamoun (Coordinator), Lara Saliba and Michel Abboud

4. **Instructional materials:**
   Lecture notes and slides provided by the instructor; practice problem sets and worksheets; past exams and solutions; solutions manual containing step-by-step solutions to the problem sets; additional references: Course prepared by Yannick Privat, University of Henri Poincare, Nancy, France.

5. **Specific course information**
   a. **Catalog description:**
      This course "Differential Calculus" is an in-depth exploration of differential equations and systems of ODEs. Fundamental concepts such as vector norms, subspaces, bases, and open and closed balls will be thoroughly detailed. Then, the students will explore the notions of convergence and equivalence between norms. The course also covers Topology by introducing fundamental concepts such as open and closed sets, adherent points, interior and boundary points. Then, a significant portion of the course is devoted to studying functions of several variables to explore concepts such as extrema and implicit functions. Finally, students learn how to calculate double and triple integrals using various methods such as Cartesian, polar, and cylindrical coordinates. The concepts and techniques studied in this course are essential for developing advanced analytical skills and solving complex mathematical problems.

   b. **Prerequisites:** 020ANGNI1 General Analysis

   c. **Required/Selected Elective/Open Elective:** Required

6. **Educational objectives for the course**
   a. **Specific outcomes of instruction:**
      - Solve linear and nonlinear differential equations.
      - Find an integrating factor to obtain exact differential equations.
      - Solve non-homogeneous first-order linear systems of differential equations.
      - Understand the fundamental concepts of normed vector spaces and positive definite symmetric bilinear forms.
      - Study the equivalence of norms and establish distances in a metric space.
      - Plot open and closed balls associated with a norm.
      - Study Topology: open and closed sets, and determine adherent points and

interior points of a domain.
- Use tools of analysis to study functions of several variables, including concepts of extrema and implicit functions.
- Identify common quadratic surfaces.
- Specify the tangent plane and normal line at a point on a surface.
- Calculate partial derivatives and total differentials of functions of several variables.
- Calculate double integrals: vertical, horizontal, and oblique sections.
- Calculate triple integrals using different methods such as Cartesian, spherical, and cylindrical coordinates.

b. PI addressed by the course:

PI	1.3
Covered	x
Assessed	x

7. Brief list of topics to be covered

- Complements of differential equations: Linear and nonlinear ODEs, integrating factor, Bernoulli's equation (2 lectures)
- Second-order differential equations: Homogeneous (constant coefficient, Euler-Cauchy, independent solutions) and non-homogeneous (Variation of parameters) (3 lectures)
- Linear first-order differential system: Homogeneous (Diagonal A, diagonalizable, trigonalizable, complex) and non-homogeneous (2 lectures)
- Introduction to the course and review of vector spaces, properties of norms (2 lectures)
- Equivalence of norms, open and closed balls associated with a norm (2 lectures)
- Introduction to topology of metric spaces
- Definition of open and closed sets (2 lectures)
- Adherent points, interior points, and boundary points of a domain (3 lectures)
- Introduction to functions of several variables, limits, continuity (2 lectures)
- Quadratic surfaces and examples (3 lectures)
- Tangent plane to a surface at a point
- Normal line to a surface at a point (2 lectures)
- Local, global, and constrained extrema
- Minimizing cost or volume of an object (3 lectures)
- Introduction to double integrals
- Calculating double integrals with vertical and horizontal slices (2 lectures)
- Calculating double integrals using polar coordinates (3 lectures)
- Introduction to triple integrals
- Calculating triple integrals in Cartesian coordinates (2 lectures)
- Calculating triple integrals in cylindrical and spherical coordinates (3 lectures)