PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA

MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

University of Medea

Faculty of Sciences

Department of Mathematics and Computer Science

Doctoral Program in Mathematics for International Students

Specialty: Partial differential equations

Objectives of the Doctoral Project

The doctoral program in Partial Differential Equations (PDEs)**,** is designed to provide a robust and multidisciplinary training that equips students with the theoretical and practical tools required to tackle complex problems in science and engineering.

One of the core objectives of this program is to build a solid foundation in advanced mathematical analysis, particularly in the theory of PDEs. This includes in-depth knowledge of existence, uniqueness, regularity of solutions, and long-term behavior of solutions to linear and nonlinear PDEs. The program places a strong emphasis on both analytical techniques (such as functional analysis, Sobolev spaces, and weak formulations) and numerical methods (such as finite element and finite difference methods), ensuring a comprehensive understanding of both theory and computation.

Another key aim is to foster interdisciplinary research by applying PDE models to a wide range of practical problems. PDEs are central to the mathematical modeling of natural and engineered systems, and the program encourages doctoral research that intersects with fields such as fluid dynamics, thermodynamics, electromagnetism, biology (e.g., chemotaxis, population dynamics), materials science, and environmental science. This interdisciplinary orientation helps bridge the gap between abstract mathematics and real-world applications.

The program also aims to train doctoral students in scientific rigor and innovation. Through a structured yet flexible research environment, students are guided to formulate original research questions, conduct rigorous analysis, and contribute novel results to the mathematical community. The development of strong research and communication skills is supported by active participation in seminars, conferences, and collaborative projects, both nationally and internationally.

In addition, the doctoral program supports professional and academic development through a variety of advanced teaching activities, including specialized coursework, workshops, summer schools, and guest lectures by renowned researchers. These activities are designed to expose students to the latest trends and open problems in PDE theory and applications, and to prepare them for academic, industrial, or research careers.

This doctoral track is closely aligned with the research directions of the Laboratory of Mathematics and its Applications**,** particularly in the areas of mathematical modeling and analysis using PDEs. The laboratory provides a dynamic research environment where students can engage in collaborative projects that contribute to national priorities and scientific advancement.

Finally, the program aims to produce highly qualified, autonomous researchers capable of addressing the mathematical challenges of our time. By combining deep theoretical expertise with practical modeling and computational skills, graduates of this program are well-equipped to contribute to innovation in critical sectors such as energy, climate modeling, biomedical engineering, and advanced manufacturing, thereby supporting sustainable development and scientific excellence.

1. Doctoral Program Committee and Thesis Supervision Team

The doctoral program in Partial Differential Equations is overseen by a qualified and multidisciplinary team of professors and researchers with expertise in mathematical analysis, modeling, and applied PDEs:

- Dr. Ayadi Hocine
- Dr. Souilah Rezak
- Dr. Bouadjila Khaled
- Dr. Benterki Abdessalem
- Dr. Aliane Mohamed

These faculty members act as doctoral advisors, research supervisors, and course instructors throughout the program.

2. Core Courses

The program offers a rigorous and well-structured set of foundational courses designed to strengthen theoretical and applied expertise:

- **Advanced Partial Differential Equations**
  Detailed study of elliptic, parabolic, and hyperbolic PDEs, including existence, uniqueness, and stability of solutions.
- **Functional Analysis**
  Exploration of Hilbert and Banach spaces, compact operators, spectral theory, and applications to PDEs.
- **Sobolev Spaces and Variational Methods**
  Study of Sobolev spaces, weak derivatives, trace theorems, and variational formulation of PDE problems.
- **Numerical Methods for PDEs**
  Finite difference and finite element techniques, consistency, convergence, and stability analysis.
- **Mathematical Modeling**
  Construction and analysis of PDE-based models in physics, biology, and engineering.
- **Seminar on Research Methodology**
  Introduction to literature review, academic writing, and presentation skills specific to PDE research.

2. Advanced Topics

Students will explore specialized areas aligned with cutting-edge developments in the field:

- **Nonlinear PDEs and Qualitative Theory**
  Study of solution behavior, blow-up phenomena, global existence, and stability.
- **Spectral Theory and Operator Analysis**
  Application of spectral methods to PDEs, eigenvalue problems, and resonance phenomena.
- **Regularity Theory**
  Investigation of the smoothness of solutions, especially under irregular data or domains.

- **Nonlocal PDEs**
  PDEs involving integral operators or fractional derivatives.
- **Control and Inverse Problems in PDEs**
  Theory and methods for controllability, observability, and parameter identification in PDE models.
- **PDEs on Irregular Domains**
  Analysis and approximation of PDEs in complex geometries and domains with singularities.

3. Supporting and Affiliated Structures

Doctoral candidates will benefit from the infrastructure and expertise provided by:

- **Laboratory of Mathematics and Its Applications**
  A research laboratory supporting theoretical and applied mathematics through seminars, collaborative research, and computing resources.

4. Curriculum Highlights and Admission Requirements

The doctoral program seeks candidates with a strong foundation in mathematical analysis and PDE theory. Admission is based on the following criteria:

- A Master’s degree in Mathematical Analysis, or a related discipline.
- Proficiency in English or French, as research activities and references may be conducted in either language.
- Submission of a research proposal that aligns with the program’s thematic areas and reflects the applicant's scientific curiosity.
- A detailed academic CV, outlining educational background, relevant coursework, and research experience.
- Two letters of recommendation from academic instructors or research mentors.
- A motivation letter describing the applicant’s research interests, academic objectives, and long-term goals.