Specialization Name: Dynamic Systems

PhD Program in Dynamic Systems

Program Overview

The PhD program in Dynamic Systems aims to develop an in-depth understanding of **Ordinary Differential Equations (ODEs)** and their theoretical and applied analysis. The program focuses on studying the **qualitative behavior of solutions, stability, chaos, control, and applications** in various fields such as **physics, engineering, biology, economics, and computational sciences**.

Core Courses

🔷 **Ordinary Differential Equations (ODEs) Theory**

- Existence and Uniqueness Theorem

- Dependence on Initial Conditions and Parameter Variations
- Series Solutions and Convergence Theories

🔷 **Stability Analysis in Dynamical Systems**

- Lyapunov Methods for Stability
- Stability of Linear and Nonlinear Systems
- Bifurcation and Phase Transitions Analysis

🔷 **Physical and Engineering Applications of Differential Equations**

- Hamiltonian Systems
- Dynamical Systems in Mechanics and Robotics
- Fluid Dynamics and Differential Equations in Aerodynamics

🔷 **Numerical Methods for Differential Equations**

- Euler and Runge-Kutta Methods for Solving ODEs
- Error and Numerical Analysis of Approximate Solutions
- Computational Programming Using MATLAB, Mathematica, and Python

🔷 **Chaos and Nonlinear Systems**

- Chaos Theory in Dynamical Systems
- Strange Attractors and Chaos Analysis
- Bifurcation Theory and Stochastic Dynamics

Advanced Topics (Additional Courses)

🔷 **Control Theory and Optimization in Dynamical Systems**

- Optimal Control
- Stochastic ODEs and Markovian Dynamical Systems
- Applications in Artificial Intelligence and Robotics

🔷 **Stochastic Differential Equations (SDEs)**

- Analysis of Stochastic Processes
- Applications in Economics, Finance, and Biological Systems

🔷 **Dynamics in Complex Systems**

- Mathematical Modeling in Dynamic Networks
- Dynamic Data Analysis and Predictive Modeling

🔷 **Spectral Analysis of Dynamical Systems**

- Fourier Analysis and Spectral Methods
- Applications in Signal Processing, Wave Phenomena, and Electrical Systems

Complete Course Table

Category	Core Courses	Advanced Courses
Mathematical Theory	- Existence and Uniqueness Theorem	- Stochastic ODEs
	- Stability Analysis Using Lyapunov Methods	- Spectral Analysis of Dynamical Systems
	- Bifurcation and Phase Transition Analysis	- Dynamics in Complex Systems
Numerical Methods	- Euler and Runge-Kutta Methods for ODEs	- Mathematical Modeling in Dynamic Networks
	- Numerical Analysis and Approximate Solution Accuracy	- Dynamic Data Analysis and Predictive Modeling
Nonlinear Systems and Chaos	- Chaos Theory and Strange Attractors	- Applications in Economics, Finance, and Biological Systems
	- Analysis of Nonlinear Dynamical Systems	- Control and Optimization in Dynamical Systems
Practical Applications	- Hamiltonian Systems and Analytical Mechanics	- Applications in Artificial Intelligence and Robotics
	- Fluid Dynamics and Aerodynamic Systems	- Markovian Dynamical Systems
Research and PhD Thesis	- Conducting Scientific Research and Publications	- PhD Dissertation Defense