



**CIMPA School on
Optimization, Convex Analysis, and Geometric Structures
January 29, 2026 to February 11, 2026**

Schedule

Week 1							
	Thursday 29-01-2026	Friday 30-01-2026	Saturday 31-01-2026	Sunday 01-02-2026	Monday 02-02-2026	Tuesday 03-02-2026	Wednesday 04-02-2026
Venue	CUI			Excursion 1	CUI		
09:30-10:30	Course 1/1	Course 3/2	Tutorial 3/2		Opening	Course 6/1	Course 4/3
10:30-10:50							
10:50-11:50	Course 2/1	Course 3/3	Tutorial 3/3		Course 4/1	Course 4/2	Course 6/2
11:50-12:00							
12:00-13:00	Discussion Time	Course 1/2	Course 1/4		Course 5/1	Course 5/2	Tutorial 6/1
13:00-14:00	Lunch Break				Lunch Break		
14:00-15:00	Course 3/1	Course 1/3	Course 2/3		Tutorial 4/1	Tutorial 4/2	Excursion 1
15:00-15:30	Tea Break				Tea Break		
15:30-16:30	Tutorial 3/1	Course 2/2	Course 2/4		Tutorial 5/1	Tutorial 5/2	
16:30-17:30				Interaction with CIMPA Scientific Officer			

Week 2							
	Thursday 05-02-2026	Friday 06-02-2026	Saturday 07-02-2026	Sunday 08-02-2026	Monday 09-02-2026	Tuesday 10-02-2026	Wednesday 11-02-2026
Venue	CUI		UMT	Excursion 2	UMT		
09:30-10:30	Course 5/3	Course 7/1	Course 9/1		Course 9/2	Course 9/3	Course 8/3
10:30-10:50	Tea Break				Tea Break		
10:50-11:50	Tutorial 5/3	Course 7/2	Tutorial 7/1		Tutorial 9/1	Course 7/3	Tutorial 7/3
11:50-12:00	Short Break				Short Break		
12:00-13:00	Tutorial 4/3	Course 8/1	Tutorial 8/1		Course 8/2	Tutorial 9/2	Tutorial 8/3
13:00-14:00	Lunch Break				Lunch Break		
14:00-15:00	Course 6/3	Panel Discussion 1	Short City Tour After Lunch		Tutorial 8/2	Tutorial 7/2	Closing
15:00-15:30	Tea Break				Tea Break	Tea Break	
15:30-16:30	Tutorial 6/2				Open Discussion		



**CIMPA School on
Optimization, Convex Analysis, and Geometric Structures
January 29, 2026 to February 11, 2026**

List of Courses

- **Course 1:** "The Fundamental Concepts of Metric Spaces" By Dr. Saad IHSAN BUTT (COMSATS University Islamabad, Lahore Campus, Pakistan) **Duration:** 4h00
- **Course 2:** "Fundamentals of Convex Analysis" By Dr. Sadia KHALID (COMSATS University Islamabad, Lahore Campus, Pakistan) **Duration:** 4h00
- **Course 3:** "Optimal Control Theory and Pontryaguin's principle By Prof. Dr. Abderrahim HANTOUTE (Universidad de Alicante, Spain) **Duration:** 6h00
- **Course 4:** "Fundamentals of Nonconvex Optimization: Separation Theorems, Generalized Derivatives and Solution Methods", "Duality in Convex and Nonconvex Optimization", "Scalarization Methods in Vector Optimization" By Prof. Dr. Refail KASIMBEYLI (Eskişehir Technical University, Turkey) **Duration:** 6h00
- **Course 5:** "Theoretical fundamentals of linear optimization" By Prof. Dr. Margarita RODRÍGUEZ (University of Alicante, Spain) **Duration:** 6h00
- **Course 6:** "Ergodic Optimization" By Dr. Shamsa Ishaq (Lahore College for Women University, Lahore) **Duration:** 5h00
- **Course 7:** "Numerical Optimization" By Prof. Dr. Adil BAGIROV (Federation University Australia, Australia) **Duration:** 6h00
- **Course 8:** "Monotone Operator Theory" By Prof. Dr. Juan ENRIQUE MARTÍNEZ LEGAZ (Universitat of Autònoma de Barcelona, Spain) **Duration:** 6h00
- **Course 9:** "Variational Methods for the Regularization of Linear Ill-posed Problems" By Prof. Dr. Pierre Maréchal (Research institute in Toulouse, France) **Duration:** 5h00
- **Panel Discussions:**
Topic 1: "Improving Research Standards in Pakistan"
Topic 2: "Making Mathematics Education More Engaging."



**CIMPA School on
Optimization, Convex Analysis, and Geometric Structures
January 29, 2026 to February 11, 2026**

Course Abstracts

Course 1: The Fundamental Concepts of Metric Spaces

Dr. Saad IHSAN BUTT (CUI, Lahore Campus, Pakistan) Duration: 4h00

This talk introduces the fundamental concepts of metric spaces through key definitions and illustrative examples, emphasizing their importance in functional analysis, particularly in the study of convergence and continuity. Essential inequalities, including Hölder's and Minkowski's inequalities, are discussed as foundational tools. The talk then explores normed spaces, focusing on their algebraic and topological properties, with attention to norms, balls, boundedness, and their relationship to convergence. Convexity in normed spaces is examined through convex sets and functions, highlighting properties such as separation and intersection. Jensen's inequality is presented as a central result for characterizing convexity, with discussion of its proof and applications in functional analysis, optimization, and probability theory. The talk also addresses linear operators on normed spaces, with emphasis on boundedness, and concludes with a brief overview of inner product spaces and their fundamental properties, providing a solid foundation for further study in functional analysis.

Course 2: Fundamentals of Convex Analysis

Dr. Sadia KHALID (CUI, Lahore Campus, Pakistan) Duration: 4h00

This course introduces the basic idea of convexity and its role in mathematics through simple definitions, geometric interpretation, illustrative examples, and its mathematical characteristics. Fundamental aspects of convexity and basic inequalities arising from it are discussed to highlight their significance. Convexity and the study of inequalities are closely connected concepts, and many well-known classical inequalities can be derived as applications of convex functions. This course focuses significantly on convexity, covering fundamental results and their key applications.

Course 3: Optimal Control Theory and Pontryagin's Principle

Prof. Dr. Abderrahim HANTOUTE (Universidad de Alicante, Spain) Duration: 6h00

The theory of dynamic optimization and optimal control dates back to the late 1940s, when it was considered a special topic of differential equations. With the discoveries of Pontryagin's



CIMPA School on
Optimization, Convex Analysis, and Geometric Structures
January 29, 2026 to February 11, 2026

principle and the development of powerful dynamic optimization tools, it has been recognized as a branch of optimization and the calculus of variations. This makes this theory an intersection of different fields, including differential equations, dynamic systems, optimization, calculus of variations, etc. Mathematically, this theory deals with dynamic systems that depend on parameters, called control parameters that interfere with the behaviour of the system. The objective is to find the exact control parameter that can take the dynamic system from an initial state to a final state, respecting some criteria intended to stabilize the system and find optimal solutions for an associated optimization criterion. In this course, the student will see the most important concepts, results and techniques of the theory of dynamic optimization and Optimal Control, and will experience its contribution to modelling and solving specific real-life problems. It will also be an opportunity to apply knowledge from other areas, such as differential equations, analysis, and optimization.

Course 4: Talk 1 “Fundamentals of Nonconvex Optimization: Separation Theorems, Generalized Derivatives and Solution Methods”

Talk 2: “Duality in Convex and Nonconvex Optimization”

Talk 3: “Scalarization Methods in Vector Optimization”

Prof. Dr. Refail KASIMBEYLI (Eskişehir Technical University, Turkey) Duration: 6h00

Talk 1 Abstract.

It is impossible to overestimate the importance of separation theorems in optimization, the role of theorems on the existence of a supporting hyperplane to a convex set at its boundary points. In this lecture, I will present some recent advances in the nonconvex analysis. Specifically, I will refer to separation theorems for nonconvex sets and their relationships with derivatives and generalized derivatives, optimality conditions and solution methods in nonconvex optimization.

Talk 2 Abstract.

In this lecture, zero duality gap conditions in nonconvex optimization are investigated. It is considered that for guaranteeing the zero duality gap property in nonconvex optimization, dual problems can be constructed with respect to the weak conjugate functions, and/or directly by using a special augmented Lagrangian formulation. We analyze the construction and investigation of dual problems by using the weak conjugate functions approach in nonconvex cases.



CIMPA School on
Optimization, Convex Analysis, and Geometric Structures
January 29, 2026 to February 11, 2026

Talk 3 Abstract.

In this lecture we provide an analysis, characterizations and comparison of some commonly used scalarization methods in multiobjective optimization. The properties of these methods are investigated with respect to the basic characteristics such as ordering cone, convexity and boundedness, the ability of generating proper efficient solutions, the ability to consider reference points and weighting preferences of decision maker.

Course 5: Theoretical fundamentals of linear optimization

Prof. Dr. Margarita RODRÍGUEZ (University of Alicante, Spain) Duration: 6h00

Typically, courses on linear optimization have as their cornerstone the classical simplex tableaux from which the theory of duality and the theory of linear systems are developed. In this course, we will reverse the order, delving into the central role played by the Fourier elimination method and the characteristic cone in the development of the theory of linear systems. We will apply these useful theoretical tools to obtain optimality, uniqueness and duality theorems and to get the geometric information on the feasible set which is basic for the right understanding of Dantzig's simplex method. The main objectives are: Fourier elimination method, characteristic cone, Weyl's theorem, Motzkin's decomposition theorem, duality, optimality and uniqueness theorems, geometry of polyhedral (boundedness, vertices, edges), simplicial paths.

Course 6: Ergodic Optimization

Dr. Shamsa Ishaq (Lahore College for Women University, Lahore) Duration: 5h00

Ergodic optimization explores the extremal behavior of dynamical systems, focusing on the characterization of maximizing orbits and invariant measures. This course provides a rigorous introduction to the fundamental tools, structured in three parts:

Foundations: This section introduces discrete dynamical systems through concrete examples, focusing on orbits and time averages. It develops the concept of invariant measures to bridge the gap between individual trajectories and global statistical behavior.

The Optimization Problem: This part focuses on identifying the specific invariant measures that maximize the space average of a given potential function.



**CIMPA School on
Optimization, Convex Analysis, and Geometric Structures
January 29, 2026 to February 11, 2026**

Thermodynamic Formalism: This section interprets optimization as the "freezing" of a system. It explores topological pressure, measure-theoretic entropy, and equilibrium states, analyzing the zero-temperature limit to demonstrate how entropy vanishes to reveal "ground states" the fundamental maximizing measures of the system.

Course 7: Numerical Optimization

Prof. Dr. Adil BAGIROV (Federation University Australia, Australia) Duration: 6h00

In this course, we start by presenting some important theoretical results from optimization including those from nonsmooth optimization. In particular, we will cover theory of subdifferentials for convex and nonconvex functions. Next, we will discuss numerical methods for solving unconstrained and constrained, smooth and nonsmooth, convex and nonconvex optimization problems. These methods include well-known smooth optimization methods such as gradient-based and (quasi)Newton-type methods as well as subgradient and bundle methods of nonsmooth optimization. Then we consider extension of these methods as well as hybrid methods and methods based on the smoothing techniques for solving nonconvex nonsmooth optimization problems. Finally, we present computer implementation of these methods and some important real-life applications.

Course 8: Monotone Operator Theory

Prof. Dr. Juan ENRIQUE MARTÍNEZ LEGAZ (Universitat of Autònoma de Barcelona, Spain) Duration: 6h00

This course provides an introduction to the theory of monotone operators, a powerful framework widely used in nonlinear functional analysis and optimization. Monotone operator theory plays a crucial role in the study of differential inclusions, variational inequalities, and convex analysis. The course will explore key concepts such as maximal monotonicity, the resolvent, and the Fitzpatrick function together with other convex representations, as well as applications in optimization.

The main objectives of the course are to study:

- 1) The fundamental properties of monotone operators.
- 2) Classical examples of monotone operators



CIMPA School on
Optimization, Convex Analysis, and Geometric Structures
January 29, 2026 to February 11, 2026

- 3) Maximally monotone operators and their characterizations.
- 4) Resolvent operators and their properties.
- 5) The maximality of the sum of maximally monotone operators.
- 6) Several concepts of generalized sums of maximally monotone operators.
- 7) Convex representations of maximally monotone operators.
- 8) Various applications of monotone operators in solving optimization problems and variational inequalities.

Course 9: Variational Methods for the Regularization of Linear Ill-posed Problems

Prof. Dr. Pierre Maréchal (Research institute in Toulouse, France) Duration: 5h00

This course is devoted to the study of variational methods for the regularization of linear ill-posed problems in infinite-dimensional spaces. Such problems arise naturally in inverse problems encountered in signal and image processing, statistics, and the analysis of partial differential equations, where solutions may fail to exist, be unique, or depend continuously on the data. The course focuses on the Hilbert space framework and emphasizes the variational formulation of regularization techniques as optimization problems. Classical Tikhonov regularization is introduced and analyzed in detail, including existence, stability, and convergence properties. Extensions to generalized and constrained Tikhonov methods are also discussed. Particular attention is paid to the role of the regularization parameter and to parameter choice strategies. Beyond standard approaches, the course highlights the variational interpretation of mollification-based regularization and its connections with smoothing and approximation theory. Theoretical results are complemented by illustrative examples and applications, providing a unified and rigorous perspective on modern regularization methods for linear inverse problems.