Numerical Analysis

Instructor: Professor Steven Dong
Course Number: MA 51400
Credits: Three
Time: 3:30–4:20 PM MWF

Catalog Description

(CS 51400) Iterative methods for solving nonlinear; linear difference equations, applications to solution of polynomial equations; differentiation and integration formulas; numerical solution of ordinary differential equations; roundoff error bounds.

Introduction To Probability

Instructor: Professor Yuan Gao
Course Number: MA 51900
Credits: Three
Time: 12:30–1:20 PM MWF

Catalog Description

(STAT 51900) Algebra of sets, sample spaces, combinatorial problems, independence, random variables, distribution functions, moment generating functions, special continuous and discrete distributions, distribution of a function of a random variable, limit theorems.

Introduction To Partial Differential Equations

Instructor: Professor Plamen Stefanov
Course Number: MA 52300
Credits: Three
Time: 10:30–11:20 AM MWF

Description

This is an introductory course in partial differential equations. I will use the book by McOwen: Partial Differential Equations: Methods and Applications, 2-nd edition, because I find it easy going but still well written and covering the needed material. We will start with first order PDEs, showing that they essentially reduce to ordinary differential equations (ODEs). Next, we will concentrate on second order PDEs. I will provide my own notes on characteristics, which extend what is in the book, and present a bit more modern view. The Cauchy–Kovalevskaya theorem will be proven and explained. Next, we will study the three basic (types of) PDEs: the wave equation, the Laplace equation, and the heat equation; all with constant coefficients, naturally, at this stage. The goal is not just to derive explicit or semi-explicit formulas for the solutions when possible but to understand the qualitive behavior of each one of them.

I will emphasize on the intuitive and on the geometric nature of the theory. Some functional analysis tools would be discussed as well to the extend possible since MA546 is not a required prerequisite. Separation of variables (leading to Fourier series or special functions expansions) will be discussed briefly but is not the main focus of the course.

Functions Of A Complex Variable I

Instructor: Professor Steven Bell
Course Number: MA 53000
Credits: Three
Time: 1:30–2:20 PM MWF

Catalog Description

Complex numbers and complex-valued functions of one complex variable; differentiation and contour integration; Cauchy's theorem; Taylor and Laurent series; residues; conformal mapping; special topics. More mathematically rigorous than MA 52500.

Probability Theory II
Instructor: Professor Christopher Janjigian
Course Number: MA 53900
Credits: Three
Time: 9:00–10:15 AM TTh

Catalog Description

(STAT 53900) Convergence of probability laws; characteristic functions; convergence to the normal law; infinitely divisible and stable laws; Brownian motion and the invariance principle.

Real Analysis And Measure Theory
Instructor: Professor Matthew Novack
Course Number: MA 54400
Credits: Three
Time: 9:30–10:20 AM MWF

Description

Sigma algebras, measures, Lebesgue integration, convergence theorems, outer measures and Caratheodory's construction, Hausdorff measure, modes of convergence, Egorov's theorem, Littlewood's three principles, Lusin's theorem, product measures, Fubini-Tonelli theorems, Lebesgue differentation theorem, Hardy-Littlewood maximal function, bounded variation, absolute continuity, elements of functional analysis (Lp spaces, Hilbert, Banach, and normed spaces), Fourier series and Parseval's theorem. Additional topics as time permits.

Functions Of Several Variables And Related Topics

Instructor: Professor Rodrigo Bañuelos
Course Number: MA 54500
Credits: Three
Time: 1:30–2:45 PM TTh

Description

PREREQUISITES: Math 544. However, depending on need, some topics from 544 may be reviewed.

DESCRIPTION: This course will cover some of the basic tools of analysis that are extremely useful in many areas of mathematics, including PDE's, stochastic analysis, harmonic analysis and complex analysis. Specific topics covered in the course include: "Geometric lemmas" (Vitali, Wiener, etc.) and "geometric decomposition theorems" (Whitney, etc.) and their applications to differentiation theory and to the Hardy–Littlewood maximal function; convolutions; approximations to the identity and their applications to boundary value problems in R^d with L^p-data; the Fourier transform and its basic properties on L^1 and L^2 (including Plancherel's theorem); interpolation theorems for linear operators (Marcinkiewicz, Riesz–Thorin); the basic (extremely elegant and useful) Calderón-Zygmund singular integral theory and some of its applications; the Hardy-Littlewood-Sobolev inequalities for fractional integration and powers of the Laplacian and other elliptic operators; the inequalities of Nash and Sobolev viewed from the point of the heat semigroup in R^d, Littlewood-Paley theory and applications to the Hörmader multiplier theorem

TEXT BOOKS: No text book is required. The course follows my Lecture Notes ("Book") *"Lectures in Analysis."* Recommended are: (1) E. M. Stein, *"Singular Integrals and Differentiability Properties of Functions"*, (2), L. Grafakos *"Modern Fourier Analysis"*.

Introduction To Abstract Algebra
Instructor: Professor Freydoon Shahidi
Course Number: MA 55300
Credits: Three
Time: 10:30–11:20 AM MWF

Catalog Description

Group theory: Sylow theorems, Jordan-Holder theorem, solvable groups. Ring theory: unique factorization in polynomial rings and principal ideal domains. Field theory: ruler and compass constructions, roots of unity, finite fields, Galois theory, solvability of equations by radicals.

Linear Algebra
Instructor: Professor Saugata Basu
Course Number: MA 55400
Credits: Three
Time: 2:30–3:20 PM MWF

Catalog Description

Review of basics: vector spaces, dimension, linear maps, matrices determinants, linear equations. Bilinear forms; inner product spaces; spectral theory; eigenvalues. Modules over a principal ideal domain; finitely generated abelian groups; Jordan and rational canonical forms for a linear transformation.

Commutative Algebra
Instructor: Professor Takumi Murayama
Course Number: MA 55700
Credits: Three
Time: 3:30–4:20 PM MWF

Description

This course is an introduction to commutative algebra. Commutative algebra is the study of commutative rings and modules and has interactions with various fields of mathematics, including algebraic geometry, number theory, and several complex variables. Planned topics include the following: A review of commutative rings and modules. Spec and the Zariski topology. Localization. Integral extensions and integral closure. Noether normalization. Hilbert's Nullstellensatz and connections to affine algebraic geometry. Chain conditions, Noetherian and Artinian rings and modules. Tensor products and flatness. Primary decomposition. Normal rings, discrete valuations rings, and Dedekind domains. Completions.

Prerequisites: MA 55300 and 55400. MA 57100 is helpful but not necessary.

Text: Course notes will be provided. The notes will largely draw from Melvin Hochster's lecture notes on commutative algebra (available at `https://dept.math.lsa.umich.edu/~hochster/614F17/614.html`).

Optional texts: All texts listed below have free access options for Purdue students.

- A term of commutative algebra by Allen B. Altman and Steven L. Kleiman (available at `https://doi.org/10.13140/RG.2.2.31866.62400`).
- Introduction to commutative algebra by Michael F. Atiyah and Ian G. Macdonald (available at `https://doi.org10.1201/9780429493638` via the Purdue library).
- Undergraduate commutative algebra by Miles Reid (available for short term loan at `https://n2t.net/ark:/13960/s27c54tjnc0`).

Introduction To Differential Geometry And Topology
Instructor: Professor Eric Samperton
Course Number: MA 56200
Credits: Three
Time: 8:30–9:20 AM MWF

Catalog Description

Smooth manifolds; tangent vectors; inverse and implicit function theorems; submanifolds; vector fields; integral curves; differential forms; the exterior derivative; DeRham cohomology groups; surfaces in E3., Gaussian curvature; two dimensional Riemannian geometry; Gauss-Bonnet and Poincare theorems on vector fields.

Elementary Topology

Instructor: Professor Jeremy Miller
Course Number: MA 57100
Credits: Three
Time: 12:30–1:20 PM MWF

Description

In this course, we will cover basic notions from point-set topology (open sets, closed sets, compact sets, bases for topologies, Hausdorff spaces, connectedness, etc.) and then discuss the fundamental group and related topics. We will use "Topology" by James R. Munkres, 2nd Edition.

Numerical Optimization

Instructor: Professor Xiangxiong Zhang
Course Number: MA 57400
Credits: Three
Time: 9:30–10:20 AM MWF

Description

This is a graduate level course focusing on introducing and analyzing practical numerical optimization algorithms which are often used in contemporary large scale machine learning problems, with a heavy emphasis on convergence analysis by monotone operator, fixed point iteration, duality in splitting methods, etc. The course will cover the following four parts with 3 4 weeks lecture time on each part:

Part I (smooth optimization): convergence and convergence rates of gradient descent, Nesterov's accelerated gradient descent, Newton, quasi-Newton and conjugate gradient methods under smoothness and convexity assumptions.

Part II (nonsmooth convex optimization): convergence and convergence rates of subgradient method, proximal gradient, and accelerated proximal gradient method, first order splitting methods including PDHG (primal dual hybrid gradient), ADMM (alternating direction method of mulipliers) and Dougas-Rachford splitting.

Part III (stochastic algorithms): convergence of randomized coordinate descent, stochastic gradient descent and Langevin dynamics.

Part IV (Riemannian optimization): this will be a brief introduction to optimization algorithms on matrix manifolds, e.g., Riemannian gradient descent and Riemannian conjugate gradient methods.

Reference books are "Introduction to Nonlinear Optimization" by Beck, "Large-Scale Convex Optimization: Algorithms & Analyses via · Monotone Operators" by Ryu and Yin, and "Optimization Algorithms on Matrix Manifolds" by Absil et al. Prerequisites are MA 511 and MA 504 (or equivalent/similar courses). Past lecture notes on the first three parts can be found on a 2023 topics course (MA 598 by Zhang in Spring 2023) webpage `https://www.math.purdue.edu/~zhan1966/teaching/598/598_2023S.html`

Graph Theory

Instructor: Professor Giulio Caviglia

Course Number: MA 57500

Credits: Three

Time: 2:30–3:20 PM MWF

Description

This is an introductory graduate–level course on Graph Theory with some emphasis on topics related to extremal combinatorics.

The texbook is GRAPH THEORY, Graduate Texts in Mathematics, Volume 244 by J. A. Bondy and U. S. R. Murty (we have a free online copy via Purdue University Libraries, for instance by using ProQuest E-book central).

We will discuss in detail the first 7 chapters, plus some other topics scattered across the book (including parts of chapters 11, 12 and 16). See the textbook for details.

Mathematical Logic I
Instructor: Professor Margaret Thomas
Course Number: MA 58500
Credits: Three
Time: 1:30–2:20 PM MWF

Description

A first course in mathematical logic, oriented towards model theory, the study of mathematical structures in terms of their logical properties. The goal is to introduce the most central ideas of mathematical logic as well as certain tools needed to explore a variety of classical and modern subjects, in particular motivated by applications of model theory (such as the Ax–Kochen–Ershov Theorem; or applications of o-minimal structures to diophantine geometry, Hodge theory, and dynamical systems; or the role of NIP and related tame structures in combinatorics; or the interaction between continuous logic and functional analysis; or connections between model theory and machine learning; etc.). Students are encouraged to participate if they are interested in possible research involving model theory, or if they are keen to learn a perspective from logic that might be applicable to other areas of mathematics.

The course will start with an introduction to predicate calculus (first-order logic), covering languages, structures, theories, formal proof, Gödel's Completeness Theorem and the Compactness Theorem of first-order logic. Thereafter, the focus will shift to central concepts in model theory, which could include definable sets, model completeness, quantifier elimination, elementary extensions, types, categoricity, saturation and ultraproducts. Set theory concepts would be introduced as needed. The emphasis will be on certain key examples, such as algebraically closed fields and o-minimal structures, with a view to some of the applications of model theory mentioned above. If there is time and interest, further topics from the foundations of mathematical logic could also be surveyed, such as a formalization of elementary number theory and the beginnings of computability, leading to the Gödel incompleteness theorems and the undecidability of arithmetic (however, given the intended focus of this course, these would not be covered in depth here).

Prerequisites: Graduate level algebra and real analysis would be advisable. (No requirement to have taken a course in logic previously.)

Analytic Theory of Function Fields

Instructor: Professor Trevor Wooley
Course Number: MA 59500AFF
Credits: Three
Time: 12:30–1:20 PM MWF

Description

Prerequisites: Elementary number theory, abstract algebra and basic analysis.

This course serves as an introduction to analytic number theory and the circle method in function fields. As such, its goal is to develop the analytic machinery designed to investigate the arithmetic properties of the polynomial ring $F_q[t]$ (polynomials with coefficients from a finite field F_q). Background results from number theory and harmonic analysis will be reviewed as needed. Students already familiar with the basic elements of analytic number theory and the circle method will acquire knowledge of more advanced topics that are part of the modern repertoire of practising researchers in these subjects.

The area of analytic number theory devoted to function field arithmetic lies at the intersection of analytic number theory, harmonic analysis and algebraic number theory. Many classical problems in analytic number theory have analogues in function fields which are more accessible to progress than in the classical setting of the rational integers. Progress in function fields motivates conjectures and new approaches in the classical setting. Meanwhile, analytic tools from the classical setting have analogues over function fields that yield progress on problems of seemingly algebraic flavour. For example, the circle method has been applied in function fields to yield new conclusions concerning the geometry of spaces of morphisms between varieties.

Our basic aims in this course are twofold: (i) to introduce the basic results on arithmetic functions and prime polynomials (i.e. monic irreducible polynomials) in function fields, and (ii) to develop the circle method in function fields using tools from harmonic analysis in this setting. Following this basic material, we will explore as many topics using these tools as time permits (distribution and properties of prime polynomials, equidistribution in function fields, Waring's problem and Vinogradov's mean value theorem in function fields, connections with geometry).

Assessment: Six problem sets will be offered through the semester, and class participants can demonstrate engagement with the course by any written and/or in-class presentations featuring a reasonable subset of these problems – three levels of difficulty: short problems testing basic skill-sets, extended problems integrating the essential methods of the course, and more challenging problems for enthusiasts with detailed hints available on request.

The course will be based on the instructor's lecture notes. Good texts for background reading and support are:

M. Rosen, Number theory in function fields, Springer, 2002 G. Effinger and D. Hayes, Additive number theory of polynomials over a finite field, Oxford, 1991

Algebraic Geometry I
Instructor: Professor Takumi Murayama
Course Number: MA 59500AG
Credits: Three
Time: 4:30–5:20 PM MWF

Description

This course is the first course in a (planned) two semester introductory sequence in algebraic geometry. Algebraic geometry is the geometric study of solutions to systems of polynomial equations. Algebraic geometry has interactions with many other fields of mathematics, including commutative algebra, algebraic topology, number theory, several complex variables, and complex geometry. This first course will mainly focus on the theory of algebraic varieties over algebraically closed fields but I plan to transition to the theory of schemes by the end of the semester. Planned topics include the following: Affine varieties. Projective varieties. Morphisms. Rational maps. Nonsingular varieties and the Jacobian criterion. Nonsingular curves. Intersections in projective space, Hilbert polynomials, and Bézout's theorem. Sheaves. Locally ringed spaces and schemes. Properties of schemes and morphisms of schemes. Sheaves of modules.

Prerequisites: MA 55300, 55400, and 57100. MA 56200 and 57200 are helpful but not necessary. Commutative algebra (similar to this semester's MA 55700) is strongly recommended (and can be taken concurrently) for Algebraic Geometry I in the fall semester. Commutative algebra will be required for Algebraic Geometry II in the spring semester.

Text: Course notes will be provided. The notes will largely draw from Algebraic geometry by Robin Hartshorne (available at `https://doi.org/10.1007/978-1-4757-3849-0` via the Purdue library).

Optional texts: All texts listed below have free access options for Purdue students. For algebraic varieties:

- Algebraic geometry: A first course by Joe Harris (available at `https://doi.org/10.1007/978-1-4757-2189-8` via the Purdue library).
- Basic algebraic geometry 1 (third edition) by Igor R. Shafarevich (available at `https://doi.org/10.1007/978-3-642-37956-7` via the Purdue library). For schemes:
- Éléments de géométrie algébrique by Alexander Grothendieck and Jean Dieudonné (available at `http://www.numdam.org/`).

- Eléments de géométrie algébrique I (second edition) by Alexander Grothendieck and Jean Dieudonné (available for short term loan at `https://n2t.net/ark:/13960/t42s6kw4b`).

Geometry and Learning for Manifold-structured Data
Instructor: Professor Rongjie Lai
Course Number: MA 59500DA
Credits: Three
Time: 10:30–11:45 AM TTh

Description

Processing and analyzing data in 3D and higher dimensions are crucial topics in many fields, such as computer vision, 3D modeling, and medical image analysis. The topics of this course include fundamental concepts of differential manifolds, computation of basic geometric quantities, numerical methods for solving variational PDEs on Riemannian manifolds, geometric deep learning-based methods for manifold-structured data, as well as their applications in shape classification, recognition, and generation.

Prerequisites: Multivariable calculus, Numerical linear algebra

Mathematical Modeling
Instructor: Professor Alexandria Volkening
Course Number: MA 59500MM
Credits: Three
Time: 9:00–10:15 AM TTh

Description

Whether predicting disease spread, helping experimentalists uncover how organisms grow and develop, determining how to reduce the frequency of traffic jams, or shedding light on climate dynamics, mathematical models are used to describe and predict systems across the natural and social world. In this class, students will gain experience building mathematical models. Modeling involves many choices, and we will discuss how to choose model complexity appropriately, identify modeling assumptions, find and handle data ethically, and present model results accessibly. This course will also involve practice problems drawn from the Mathematical Contest in Modeling (https://www.comap.com/contests/mcm-icm) database. For graduate students who take this course as MA59500MM, the modeling projects will be more involved.

Pre-requisite: Ordinary differential equations (i.e., MA 266, 366, or 303) and linear algebra. Some experience with programming is encouraged.

Textbook: No textbook is required for this course, and course material will include instructor notes.

Quantum Computing

Instructor: Professor Ralph Kaufmann
Course Number: MA 59500QC
Credits: Three
Time: 9:00–10:15 PM TTh

Description

This course will be an introduction to the theory underlying quantum computing and topological quantum computing. The course is designed to be self-contained. We will start with the basics of boolean logic and its quantum generalization in terms of gates and U(n) actions. The quantum mechanical background from physics will also be given and a deeper discussion of spins and their representation theoretic description is planned. Starting from this paradigmatic example, the course will move to aspects needed for topological quantum computing or field theoretical formulations. The last part of the course will be dedicated to additional topics from the list below which best fit the audience.

The course is open to anyone in mathematics, physics, computer science, chemistry, science or engineering, but a good understanding of linear algebra, e.g. MA 511, will be very helpful in understanding the concepts.

The basic outline is as follows:

1. Boolean logic.
2. Complex vector spaces.
3. $U(2), SU(2), U(n)$ and representation theory of these (see also 9)
4. Tensor products
5. Quantum gates I
6. Basic quantum mechanics/phases (projective representations)
7. Bloch Sphere
8. Quantum gates II (projective version)
9. Spin and Spin coupling, Clebsch Gordan coefficients, 6j symbols
10. Representation categories
11. Monoidal, symmetric monoidal, braided monoidal categories, spherical, pivotal etc.
12. Examples via representations of Hopf algebras. (maybe Drinfel'd doubles)

Additional topics (depending on the audience)

A) Quantum program examples, eg. Shor's algorithm.

B) Nearest neighbor actions

C) Spin chain Hamiltonians

D) Lattices and Toric code.

E) D-branes and boundary conditions.

F) Categorical actions and Hochschild complexes for E).

G) Quantum error correction

Introduction to Additive Combinatorics
Instructor: Professor Ilia Shkredov
Course Number: MA 59500SP
Credits: Three
Time: 3:00–4:15 PM TTh

Description

Additive combinatorics is a rapidly developing new field of modern mathematics, lying between number theory and combinatorics. A variety of tools are used such as (besides number theory and combinatorics) dynamical systems, computer science, probability, geometry, algebra and so on. Roughly speaking, additive combinatorics is the field that studies combinatorial problems that can be expressed through the group operation.

To get an idea of additive combinatorics, you can refer to the first result in this area, namely the famous Cauchy theorem (1813) concerning addition in Z/pZ, which says that the power of the sum $A + B := a + b : a \in A, b \in B$ of two sets A, B from Z/pZ is either p or at minimum $|A| + |B| - 1$. Thus, we have a general combinatorial statement for arbitrary sets, but this combinatorics includes the group operation $+$. Other results of additive combinatorics are those of van der Waerden theorem on arithmetic progressions (which Khintchin called "a pearl of number theory"), Freiman's structural result on sumsets, the amazing Green-Tao theorem on arithmetic progressions in the prime numbers, Bourgain–Glibichuk–Konyagin theorem on the uniform distribution of multiplicative subgroups and many others.

In this course we plan to introduce you to the fundamental results of the area and describe some relationships and connections of additive combinatorics with number theory, combinatorics, ergodic theory, graph theory, Fourier analysis, geometry and other branches of mathematics.

Extended Programm:

1. Introduction, coloring problems.
2. Combinatorial ergodic theory and the regularity lemma.
3. Sumsets and difference sets.
4. Applications of Fourier analysis to additive combinatorics.
5. Sets having no arithmetic progressions of length three.
6. Bohr sets and the spectrum.
7. Almost periodicity.
8. Freiman's theorem on sets with small doubling.
9. The sum-product phenomenon: the real case.
10. The sum-product phenomenon: the finite fields case.
11. Gowers norms.
12. Multiplicative combinatorics.

Book: Terence Tao and Van H. Vu, Additive combinatorics

Prerequisites: 16*** (first year calculus).

All levels, undergraduate/graduate.

Modern Differential Geometry
Instructor: Professor Lvzhou Chen
Course Number: MA 66100
Credits: Three

Time: 11:30 AM–12:20 PM   MWF

Description

In the first part of the course, we will cover some standard materials in Riemannian geometry. This includes the notion of Riemannian metric (allowing us to measure lengths and angles of curves) on differentiable manifolds, connection, geodesic, curvature, parallel transportation, etc. We will discuss how geometry (especially curvature) interacts with topology of the manifold.

In the second part of the course, we will focus on Riemannian manifolds with nice symmetries, for which we can understand the geometry based on the isometry group. We will discuss hyperbolic geometry in detail and explain the important role it plays in understanding manifolds in low dimensions (two and three).

Prerequisites: include (1) MA 562, especially familiarity with differentiable manifolds, tangent space, vector fields, differential forms, (2) some materials from MA 571 and 572, such as compactness, completeness, covering spaces, and fundamental groups.

Topics in Commutative Algebra: Positive characteristic methods

Instructor: Professor Linquan Ma
Course Number: MA 69000PC
Credits: Three
Time: 9:30–10:20 AM   MWF

Description

We will give an introduction to singularities in positive characteristic, defined and studied via the Frobenius map. Specific topics include Kunz's theorem, F-purity and Frobenius splitting, F-regularity, Frobenius structure on local cohomology, F-injectivity and F-rationality, numerical invariants such as F-signature, and if time permitting, connections to singularities in birational geometry.

The main reference is `https://www.math.purdue.edu/~ma326/F-singularitiesBook.pdf` (though we might add some additional topics). The prerequisites are basic commutative algebra and chapters 1–3 of Bruns and Herzog.

Matrix Methods for Data Science
Instructor: Professor Jianlin Xia
Course Number: MA 69200MM
Credits: Three
Time: 1:30–2:45 PM TTh

Description

Matrix methods play a key computational role in modern data analysis, scientific computing, and engineering simulations. The course will cover some useful matrix methods for several data science topics. We will focus on fast and efficient matrix computations that can benefit machine learning, data analysis, and also other numerical computations. Selected topics include:

1. Matrix models of neural networks and machine learning.
2. Data matrices and matrix decompositions.
3. Randomized data probing, compression, and approximation.
4. Stochastic/randomized solvers for linear algebra and optimization.
5. Kernel matrix methods and fast transformations.
6. Fast multipole methods and structured matrices.
7. Fast direct solvers and eigenvalue solvers with applications to data analysis.
8. Applications to PDE solutions and approximations.

Knowledge in basic numerical analysis and linear algebra is strongly suggested. There will be no comprehensive final exam. Reference books/papers, lecture notes, test codes, and other resources will be provided.

Bounded Cohomology

Instructor: Professors Lvzhou Chen; Sam Nariman

Course Number: MA 69700BC

Credits: Three

Time: 1:30–2:20 PM MWF

Description

Bounded cohomology gives invariants of spaces or groups that capture geometric, topological, and dynamical information. It provides a useful set of tools and points of views for the study of (hyperbolic) geometry, (low-dimensional) topology, and group actions on manifolds. It is different from the ordinary cohomology group in many ways: There is a natural sup norm on bounded cohomology groups; It often captures more refined data; It is frequently infinite dimensional and harder to compute.

We plan to cover basic definitions and properties, low degree examples, the dual notion of Gromov norm of homology classes, the simplicial volume of manifolds and why it is proportional to the hyperbolic volume for hyperbolic manifolds, how bounded cohomology helps us understand the Gromov norm and simplicial volume. We will also discuss various applications, such as the Mostow rigidity, classification of group actions on the circle, the Milnor–Wood inequality, and rigidity of actions on low-dimensional manifolds (e.g. the circle and surfaces).

We assume some basic knowledge in algebraic topology, differential geometry, manifolds, and group actions.