Algebraic Topology A Primer

This book is about toric topology, a new area of mathematics
that emerged at the end of the 1990s on the border of
equivariant topology, algebraic and symplectic geometry,
combinatorics, and commutative algebra. It has quickly grown
into a very active area with many links to other areas of
mathematics, and continues to attract experts from different
fields. The key players in toric topology are moment-angle
manifolds, a class of manifolds with torus actions defined in
combinatorial terms. Construction of moment-angle manifolds
relates to combinatorial geometry and algebraic geometry of
toric varieties via the notion of a quasitoric manifold.
Discovery of remarkable geometric structures on moment-
angle manifolds led to important connections with classical
and modern areas of symplectic, Lagrangian, and non-
Kaehler complex geometry. A related categorical construction
of moment-angle complexes and polyhedral products
provides for a universal framework for many fundamental
constructions of homotopical topology. The study of
polyhedral products is now evolving into a separate subject of
homotopy theory. A new perspective on torus actions has
also contributed to the development of classical areas of
algebraic topology, such as complex cobordism. This book
includes many open problems and is addressed to experts
interested in new ideas linking all the subjects involved, as
well as to graduate students and young researchers ready to
enter this beautiful new area.
Spectral sequences are among the most elegant and
powerful methods of computation in mathematics. This book
describes some of the most important examples of spectral
sequences and some of their most spectacular applications.
The first part treats the algebraic foundations for this sort of

homological algebra, starting from informal calculations. The heart of the text is an exposition of the classical examples from homotopy theory, with chapters on the Leray-Serre spectral sequence, the Eilenberg-Moore spectral sequence, the Adams spectral sequence, and, in this new edition, the Bockstein spectral sequence. The last part of the book treats applications throughout mathematics, including the theory of knots and links, algebraic geometry, differential geometry and algebra. This is an excellent reference for students and researchers in geometry, topology, and algebra.

This book focuses on the algebraic-topological aspects of probability theory, leading to a wider and deeper understanding of basic theorems, such as those on the structure of continuous convolution semigroups and the corresponding processes with independent increments. The method applied within the setting of Banach spaces and of locally compact Abelian groups is that of the Fourier transform. This analytic tool along with the relevant parts of harmonic analysis makes it possible to study certain properties of stochastic processes in dependence of the algebraic-topological structure of their state spaces. Graduate students, lecturers and researchers may use the book as a primer in the theory of probability measures on groups and related structures.This book has been selected for coverage in: ? CC / Physical, Chemical & Earth Sciences? Index to Scientific Book Contents? (ISBC)

Self-contained introduction to quantum groups as algebraic objects, suitable as a textbook for graduate courses.

In this book, two seemingly unrelated fields -- algebraic topology and robust control -- are brought together. The book develops algebraic/differential topology from an application-oriented point of view. The book takes the reader on a path starting from a well-motivated robust stability problem, showing the relevance of the simplicial approximation

theorem and how it can be efficiently implemented using computational geometry. The simplicial approximation theorem serves as a primer to more serious topological issues such as the obstruction to extending the Nyquist map, K-theory of robust stabilization, and eventually the differential topology of the Nyquist map, culminating in the explanation of the lack of continuity of the stability margin relative to rounding errors. The book is suitable for graduate students in engineering and/or applied mathematics, academic researchers and governmental laboratories.

Differential geometry and topology have become essential tools for many theoretical physicists. In particular, they are indispensable in theoretical studies of condensed matter physics, gravity, and particle physics. Geometry, Topology and Physics, Second Edition introduces the ideas and techniques of differential geometry and topology at a level suitable for postgraduate students and researchers in these fields. The second edition of this popular and established text incorporates a number of changes designed to meet the needs of the reader and reflect the development of the subject. The book features a considerably expanded first chapter, reviewing aspects of path integral quantization and gauge theories. Chapter 2 introduces the mathematical concepts of maps, vector spaces, and topology. The following chapters focus on more elaborate concepts in geometry and topology and discuss the application of these concepts to liquid crystals, superfluid helium, general relativity, and bosonic string theory. Later chapters unify geometry and topology, exploring fiber bundles, characteristic classes, and index theorems. New to this second edition is the proof of the index theorem in terms of supersymmetric quantum mechanics. The final two chapters are devoted to the most fascinating applications of geometry and topology in contemporary physics, namely the study of anomalies in

gauge field theories and the analysis of Polakov's bosonic string theory from the geometrical point of view. Geometry, Topology and Physics, Second Edition is an ideal introduction to differential geometry and topology for postgraduate students and researchers in theoretical and mathematical physics.

Combining concepts from topology and algorithms, this book delivers what its title promises: an introduction to the field of computational topology. Starting with motivating problems in both mathematics and computer science and building up from classic topics in geometric and algebraic topology, the third part of the text advances to persistent homology. This point of view is critically important in turning a mostly theoretical field of mathematics into one that is relevant to a multitude of disciplines in the sciences and engineering. The main approach is the discovery of topology through algorithms. The book is ideal for teaching a graduate or advanced undergraduate course in computational topology, as it develops all the background of both the mathematical and algorithmic aspects of the subject from first principles. Thus the text could serve equally well in a course taught in a mathematics department or computer science department. This book consists of two parts. The first is devoted to an introduction to basic concepts in algebraic geometry: affine and projective varieties, some of their main attributes and examples. The second part is devoted to the theory of curves: local properties, affine and projective plane curves, resolution of singularities, linear equivalence of divisors and linear series, Riemann Roch and Riemann urwitz Theorems. The approach in this book is purely algebraic. The main tool is commutative algebra, from which the needed results are recalled, in most cases with proofs. The prerequisites consist of the knowledge of basics in affine and projective geometry, basic algebraic concepts regarding rings, modules, fields,

linear algebra, basic notions in the theory of categories, and some elementary point et topology. This book can be used as a textbook for an undergraduate course in algebraic geometry. The users of the book are not necessarily intended to become algebraic geometers but may be interested students or researchers who want to have a first smattering in the topic. The book contains several exercises, in which there are more examples and parts of the theory that are not fully developed in the text. Of some exercises, there are solutions at the end of each chapter.

The theory of persistence modules originated in topological data analysis and became an active area of research in algebraic topology. This book provides a concise and self-contained introduction to persistence modules and focuses on their interactions with pure mathematics, bringing the reader to the cutting edge of current research. In particular, the authors present applications of persistence to symplectic topology, including the geometry of symplectomorphism groups and embedding problems. Furthermore, they discuss topological function theory, which provides new insight into oscillation of functions. The book is accessible to readers with a basic background in algebraic and differential topology.

This is the first of two volumes on the qualitative theory of foliations. This volume is divided into three parts. It is extensively illustrated throughout and provides a large number of examples. Part 1 is intended as a "primer" in foliation theory. A working

knowledge of manifold theory and topology is a prerequisite. Fundamental definitions and theorems are explained to prepare the reader for further exploration of the topic. This section places considerable emphasis on the construction of examples, which are accompanied by many illustrations. Part 2 considers foliations of codimension one. Using very hands-on geometric methods, the path leads to a complete structure theory (the theory of levels), which was established by Conlon along with Cantwell, Hector, Duminy, Nishimori, Tsuchiya, et al. Presented here is the first and only full treatment of the theory of levels in a textbook. Part 3 is devoted to foliations of higher codimension, including abstract laminations (foliated spaces). The treatment emphasizes the methods of ergodic theory: holonomy-invariant measures and entropy. Featured are Sullivan's theory of foliation cycles, Plante's theory of growth of leaves, and the Ghys, Langevin, Walczak theory of geometric entropy. This comprehensive volume has something to offer a broad spectrum of readers: from beginners to advanced students to professional researchers. Packed with a wealth of illustrations and copious examples at varying degrees of difficulty, this highly-accessible text offers the first full treatment in the literature of the theory of levels for foliated manifolds of codimension one. It would make an elegant supplementary text for a topics course at the

advanced graduate level. Foliations II is Volume 60 in the AMS in the Graduate Studies in Mathematics series.

A graph complex is a finite family of graphs closed under deletion of edges. Graph complexes show up naturally in many different areas of mathematics. Identifying each graph with its edge set, one may view a graph complex as a simplicial complex and hence interpret it as a geometric object. This volume examines topological properties of graph complexes, focusing on homotopy type and homology. Many of the proofs are based on Robin Forman's discrete version of Morse theory.

Topology is a large subject with many branches broadly categorized as algebraic topology, point-set topology, and geometric topology. Point-set topology is the main language for a broad variety of mathematical disciplines. Algebraic topology serves as a powerful tool for studying the problems in geometry and numerous other areas of mathematics. Elements of Topology provides a basic introduction to point-set topology and algebraic topology. It is intended for advanced undergraduate and beginning graduate students with working knowledge of analysis and algebra. Topics discussed include the theory of convergence, function spaces, topological transformation groups, fundamental groups, and covering spaces. The author makes the subject accessible by providing

more than 250 worked examples and counterexamples with applications. The text also includes numerous end-of-section exercises to put the material into context. The academic year 1996-97 was designated as a special year in Algebraic Topology at Northwestern University (Evanston, IL). In addition to guest lecturers and special courses, an international conference was held entitled ""Current trends in algebraic topology with applications to algebraic geometry and physics"". The series of plenary lectures included in this volume indicate the great breadth of the conference and the lively interaction that took place among various areas of mathematics. Original research papers were submitted, and all submissions were refereed to the usual journal standards. It features a paper prepared by C. Rezk on the Hopkins-Miller theorem, and a set of problems presented at a special problem session held at the conference.

This book provides an accessible introduction to algebraic topology, a field at the intersection of topology, geometry and algebra, together with its applications. Moreover, it covers several related topics that are in fact important in the overall scheme of algebraic topology. Comprising eighteen chapters and two appendices, the book integrates various concepts of algebraic topology, supported by examples, exercises, applications and historical

notes. Primarily intended as a textbook, the book offers a valuable resource for undergraduate, postgraduate and advanced mathematics students alike. Focusing more on the geometric than on algebraic aspects of the subject, as well as its natural development, the book conveys the basic language of modern algebraic topology by exploring homotopy, homology and cohomology theories, and examines a variety of spaces: spheres, projective spaces, classical groups and their quotient spaces, function spaces, polyhedra, topological groups, Lie groups and cell complexes, etc. The book studies a variety of maps, which are continuous functions between spaces. It also reveals the importance of algebraic topology in contemporary mathematics, theoretical physics, computer science, chemistry, economics, and the biological and medical sciences, and encourages students to engage in further study. This book consists of two parts. The first is devoted to an introduction to basic concepts in algebraic geometry: affine and projective varieties, some of their main attributes and examples. The second part is devoted to the theory of curves: local properties, affine and projective plane curves, resolution of singularities, linear equivalence of divisors and linear series, Riemann–Roch and Riemann–Hurwitz Theorems. The approach in this book is purely algebraic. The main tool is commutative algebra, from which the needed results are recalled, in most

cases with proofs. The prerequisites consist of the knowledge of basics in affine and projective geometry, basic algebraic concepts regarding rings, modules, fields, linear algebra, basic notions in the theory of categories, and some elementary point–set topology. This book can be used as a textbook for an undergraduate course in algebraic geometry. The users of the book are not necessarily intended to become algebraic geometers but may be interested students or researchers who want to have a first smattering in the topic. The book contains several exercises, in which there are more examples and parts of the theory that are not fully developed in the text. Of some exercises, there are solutions at the end of each chapter.

The fundamental mathematical tools needed to understand machine learning include linear algebra, analytic geometry, matrix decompositions, vector calculus, optimization, probability and statistics. These topics are traditionally taught in disparate courses, making it hard for data science or computer science students, or professionals, to efficiently learn the mathematics. This self-contained textbook bridges the gap between mathematical and machine learning texts, introducing the mathematical concepts with a minimum of prerequisites. It uses these concepts to derive four central machine learning methods: linear regression, principal component analysis, Gaussian mixture models and

support vector machines. For students and others with a mathematical background, these derivations provide a starting point to machine learning texts. For those learning the mathematics for the first time, the methods help build intuition and practical experience with applying mathematical concepts. Every chapter includes worked examples and exercises to test understanding. Programming tutorials are offered on the book's web site.

This monograph presents an application of concepts and methods from algebraic topology to models of concurrent processes in computer science and their analysis. Taking well-known discrete models for concurrent processes in resource management as a point of departure, the book goes on to refine combinatorial and topological models. In the process, it develops tools and invariants for the new discipline directed algebraic topology, which is driven by fundamental research interests as well as by applications, primarily in the static analysis of concurrent programs. The state space of a concurrent program is described as a higher-dimensional space, the topology of which encodes the essential properties of the system. In order to analyse all possible executions in the state space, more than "just" the topological properties have to be considered: Execution paths need to respect a partial order given by the time flow. As a result, tools and concepts from topology have to be extended to take privileged directions into account. The target audience for this book consists of graduate students, researchers and practitioners in the field, mathematicians and computer scientists alike.

This book is written as a textbook on algebraic topology. The first part covers the material for two introductory courses

about homotopy and homology. The second part presents more advanced applications and concepts (duality, characteristic classes, homotopy groups of spheres, bordism). The author recommends starting an introductory course with homotopy theory. For this purpose, classical results are presented with new elementary proofs. Alternatively, one could start more traditionally with singular and axiomatic homology. Additional chapters are devoted to the geometry of manifolds, cell complexes and fibre bundles. A special feature is the rich supply of nearly 500 exercises and problems. Several sections include topics which have not appeared before in textbooks as well as simplified proofs for some important results. Prerequisites are standard point set topology (as recalled in the first chapter), elementary algebraic notions (modules, tensor product), and some terminology from category theory. The aim of the book is to introduce advanced undergraduate and graduate (master's) students to basic tools, concepts and results of algebraic topology. Sufficient background material from geometry and algebra is included.

This volume is the first comprehensive treatment of combinatorial algebraic topology in book form. The first part of the book constitutes a swift walk through the main tools of algebraic topology. Readers - graduate students and working mathematicians alike - will probably find particularly useful the second part, which contains an in-depth discussion of the major research techniques of combinatorial algebraic topology. Although applications are sprinkled throughout the second part, they are principal focus of the third part, which is entirely devoted to developing the topological structure theory for graph homomorphisms.

The ultimate goal of this book is to explain that the Grothendieck–Teichmüller group, as defined by Drinfeld in quantum group theory, has a topological interpretation as a

group of homotopy automorphisms associated to the little 2-disc operad. To establish this result, the applications of methods of algebraic topology to operads must be developed. This volume is devoted primarily to this subject, with the main objective of developing a rational homotopy theory for operads. The book starts with a comprehensive review of the general theory of model categories and of general methods of homotopy theory. The definition of the Sullivan model for the rational homotopy of spaces is revisited, and the definition of models for the rational homotopy of operads is then explained. The applications of spectral sequence methods to compute homotopy automorphism spaces associated to operads are also explained. This approach is used to get a topological interpretation of the Grothendieck–Teichmüller group in the case of the little 2-disc operad. This volume is intended for graduate students and researchers interested in the applications of homotopy theory methods in operad theory. It is accessible to readers with a minimal background in classical algebraic topology and operad theory.

The Handbook of Homotopy Theory provides a panoramic view of an active area in mathematics that is currently seeing dramatic solutions to long-standing open problems, and is proving itself of increasing importance across many other mathematical disciplines. The origins of the subject date back to work of Henri Poincaré and Heinz Hopf in the early 20th century, but it has seen enormous progress in the 21st century. A highlight of this volume is an introduction to and diverse applications of the newly established foundational theory of ¥ -categories. The coverage is vast, ranging from axiomatic to applied, from foundational to computational, and includes surveys of applications both geometric and algebraic. The contributors are among the most active and creative researchers in the field. The 22 chapters by 31 contributors are designed to address novices, as well as

established mathematicians, interested in learning the state of the art in this field, whose methods are of increasing importance in many other areas.

The purpose of this book is to give background for those who would like to delve into some higher category theory. It is not a primer on higher category theory itself. It begins with a paper by John Baez and Michael Shulman which explores informally, by analogy and direct connection, how cohomology and other tools of algebraic topology are seen through the eyes of n-category theory. The idea is to give some of the motivations behind this subject. There are then two survey articles, by Julie Bergner and Simona Paoli, about (infinity,1) categories and about the algebraic modelling of homotopy n-types. These are areas that are particularly well understood, and where a fully integrated theory exists. The main focus of the book is on the richness to be found in the theory of bicategories, which gives the essential starting point towards the understanding of higher categorical structures. An article by Stephen Lack gives a thorough, but informal, guide to this theory. A paper by Larry Breen on the theory of gerbes shows how such categorical structures appear in differential geometry. This book is dedicated to Max Kelly, the founder of the Australian school of category theory, and an historical paper by Ross Street describes its development. The study of the mapping class group Mod(S) is a classical topic that is experiencing a renaissance. It lies at the juncture of geometry, topology, and group theory. This book explains as many important theorems, examples, and techniques as possible, quickly and directly, while at the same time giving full details and keeping the text nearly self-contained. The book is suitable for graduate students. A Primer on Mapping Class Groups begins by explaining the main group-theoretical properties of Mod(S), from finite generation by Dehn twists and low-dimensional homology to the Dehn-Nielsen-Baer

theorem. Along the way, central objects and tools are introduced, such as the Birman exact sequence, the complex of curves, the braid group, the symplectic representation, and the Torelli group. The book then introduces Teichmüller space and its geometry, and uses the action of Mod(S) on it to prove the Nielsen-Thurston classification of surface homeomorphisms. Topics include the topology of the moduli space of Riemann surfaces, the connection with surface bundles, pseudo-Anosov theory, and Thurston's approach to the classification.

Building on rudimentary knowledge of real analysis, point-set topology, and basic algebra, Basic Algebraic Topology provides plenty of material for a two-semester course in algebraic topology. The book first introduces the necessary fundamental concepts, such as relative homotopy, fibrations and cofibrations, category theory, cell complexes, and si Presents the theory of local Chern characters used in commutative algebra in an algebraic setting.

The book was easy to understand, with many examples. The exercises were well chosen, and served to give further examples and developments of the theory. --William Goldman, University of Maryland In this book, Miranda takes the approach that algebraic curves are best encountered for the first time over the complex numbers, where the reader's classical intuition about surfaces, integration, and other concepts can be brought into play. Therefore, many examples of algebraic curves are presented in the first chapters. In this way, the book begins as a primer on Riemann surfaces, with complex charts and meromorphic functions taking center stage. But the main examples come from projective curves, and slowly but surely the text moves toward the algebraic category. Proofs of the Riemann-Roch and Serre Duality Theorems are presented in an algebraic manner, via an adaptation of the adelic proof, expressed

completely in terms of solving a Mittag-Leffler problem. Sheaves and cohomology are introduced as a unifying device in the latter chapters, so that their utility and naturalness are immediately obvious. Requiring a background of one semester of complex variable theory and a year of abstract algebra, this is an excellent graduate textbook for a second-semester course in complex variables or a year-long course in algebraic geometry. This book introduces D-modules and their applications avoiding all unnecessary over-sophistication. Algebraic topology is a basic part of modern mathematics, and some knowledge of this area is indispensable for any advanced work relating to geometry, including topology itself, differential geometry, algebraic geometry, and Lie groups. This book provides a detailed treatment of algebraic topology both for teachers of the subject and for advanced graduate students in mathematics either specializing in this area or continuing on to other fields. J. Peter May's approach reflects the enormous internal developments within algebraic topology over the past several decades, most of which are largely unknown to mathematicians in other fields. But he also retains the classical presentations of various topics where appropriate. Most chapters end with problems that further explore and refine the concepts presented. The final four chapters provide sketches of substantial areas of algebraic topology that are normally omitted from introductory texts, and the book concludes with a list of suggested readings for those interested in delving further into the field. This book presents a coherent suite of computational tools for the study of group cohomology algebraic cycles. With firm foundations dating only from the 1950s, algebraic topology is a relatively young area of mathematics. There are very few textbooks that treat fundamental topics beyond a first course, and many topics now essential to the field are not

treated in any textbook. J. Peter May's A Concise Course in Algebraic Topology addresses the standard first course material, such as fundamental groups, covering spaces, the basics of homotopy theory, and homology and cohomology. In this sequel, May and his coauthor, Kathleen Ponto, cover topics that are essential for algebraic topologists and others interested in algebraic topology, but that are not treated in standard texts. They focus on the localization and completion of topological spaces, model categories, and Hopf algebras. The first half of the book sets out the basic theory of localization and completion of nilpotent spaces, using the most elementary treatment the authors know of. It makes no use of simplicial techniques or model categories, and it provides full details of other necessary preliminaries. With these topics as motivation, most of the second half of the book sets out the theory of model categories, which is the central organizing framework for homotopical algebra in general. Examples from topology and homological algebra are treated in parallel. A short last part develops the basic theory of bialgebras and Hopf algebras.

This book offers an essential introduction to the theory of Hilbert space, a fundamental tool for non-relativistic quantum mechanics. Linear, topological, metric, and normed spaces are all addressed in detail, in a rigorous but reader-friendly fashion. The rationale for providing an introduction to the theory of Hilbert space, rather than a detailed study of Hilbert space theory itself, lies in the strenuous mathematics demands that even the simplest physical cases entail. Graduate courses in physics rarely offer enough time to cover the theory of Hilbert space and operators, as well as distribution theory, with sufficient mathematical rigor. Accordingly, compromises must be found between full rigor and the practical use of the instruments. Based on one of the authors's lectures on functional analysis for graduate

students in physics, the book will equip readers to approach Hilbert space and, subsequently, rigged Hilbert space, with a more practical attitude. It also includes a brief introduction to topological groups, and to other mathematical structures akin to Hilbert space. Exercises and solved problems accompany the main text, offering readers opportunities to deepen their understanding. The topics and their presentation have been chosen with the goal of quickly, yet rigorously and effectively, preparing readers for the intricacies of Hilbert space. Consequently, some topics, e.g., the Lebesgue integral, are treated in a somewhat unorthodox manner. The book is ideally suited for use in upper undergraduate and lower graduate courses, both in Physics and in Mathematics. This book contains 23 papers of open problems and directions about mapping class groups and related topics. The papers focus on aspects deeply connected with geometric topology, combinatorial group theory and surrounding areas. This book is based on lectures given at a summer school on motivic homotopy theory at the Sophus Lie Centre in Nordfjordeid, Norway, in August 2002. Aimed at graduate students in algebraic topology and algebraic geometry, it contains background material from both of these fields, as well as the foundations of motivic homotopy theory. It will serve as a good introduction as well as a convenient reference for a broad group of mathematicians to this important and fascinating new subject. Vladimir Voevodsky is one of the founders of the theory and received the Fields medal for his work, and the other authors have all done important work in the subject. The purpose of this book is to prepare the reader for

coping with abstract mathematics. The intended audience is both students taking a first course in abstract algebra who feel the need to strengthen their background and those from a more applied background who need some experience in dealing with abstract ideas. Learning any area of abstract mathematics requires not only ability to write formally but also to think intuitively about what is going on and to describe that process clearly and cogently in ordinary English. Ash tries to aid intuition by keeping proofs short and as informal as possible and using concrete examples as illustration. Thus, it is an ideal textbook for an audience with limited experience in formalism and abstraction. A number of expository innovations are included, for example, an informal development of set theory which teaches students all the basic results for algebra in one chapter.

The single most difficult thing one faces when one begins to learn a new branch of mathematics is to get a feel for the mathematical sense of the subject. The purpose of this book is to help the aspiring reader acquire this essential common sense about algebraic topology in a short period of time. To this end, Sato leads the reader through simple but meaningful examples in concrete terms. Moreover, results are not discussed in their greatest possible generality, but in terms of the simplest and most essential cases. In response to suggestions from readers of the original edition of this book, Sato has added an appendix of useful definitions and results on sets, general topology, groups and such. He has also provided references. Topics covered include

fundamental notions such as homeomorphisms, homotopy equivalence, fundamental groups and higher homotopy groups, homology and cohomology, fiber bundles, spectral sequences and characteristic classes. Objects and examples considered in the text include the torus, the Mobius strip, the Klein bottle, closed surfaces, cell complexes and vector bundles.
This volume records the lectures given at a conference to celebrate Professor Ioan James' 60th birthday.
This self-contained introduction to algebraic topology is suitable for a number of topology courses. It consists of about one quarter 'general topology' (without its usual pathologies) and three quarters 'algebraic topology' (centred around the fundamental group, a readily grasped topic which gives a good idea of what algebraic topology is). The book has emerged from courses given at the University of Newcastle-upon-Tyne to senior undergraduates and beginning postgraduates. It has been written at a level which will enable the reader to use it for self-study as well as a course book. The approach is leisurely and a geometric flavour is evident throughout. The many illustrations and over 350 exercises will prove invaluable as a teaching aid. This account will be welcomed by advanced students of pure mathematics at colleges and universities.
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