

## The Topos Of Music Geometric Logic Of Concepts Theory And Performance 1st Edition

Questions about variation, similarity, enumeration, and classification of musical structures have long intrigued both musicians and mathematicians. Mathematical models can be found from theoretical analysis to actual composition or sound production. Increasingly in the last few decades, musical scholarship has incorporated modern mathematical content. One example is the application of methods from Algebraic Combinatorics, or Topology and Graph Theory, to the classification of different musical objects. However, these applications of mathematics in the understanding of music have also led to interesting open problems in mathematics itself. The reach and depth of the contributions on mathematical music theory presented in this volume is significant. Each contribution is in a section within these subjects: (i) Algebraic and Combinatorial Approaches; (ii) Geometric, Topological, and Graph-Theoretical Approaches; and (iii) Distance and Similarity Measures in Music. remove

Drawing inspiration from John Cage's, *Notations*, *Notations 21* features illustrated musical scores from more than 100 international composers, all of whom are making amazing breakthroughs in the art of notation. These spectacularly beautiful and fascinatingly creative visual pieces not only make for exciting music, but inspiring visual art as well. The scores are accompanied by written contributions from the artists that explore every facet of their creative processes, from inspiration to execution. Contributors include the likes of Karlheinz Stockhausen, Earle Brown, Halim El-Dabh, Joan La Barbara, and Yuji Takahashi, as well as emerging composers whose compositions are also visually astounding and important. In the spirit of honoring the 40th anniversary of Cage's seminal book, while furthering it in a 21st century context, a portion of the sales will be donated to the Foundation for Contemporary Performing Arts.

After the development of manifolds and algebraic varieties in the previous century, mathematicians and physicists have continued to advance concepts of space. This book and its companion explore various new notions of space, including both formal and conceptual points of view, as presented by leading experts at the *New Spaces in Mathematics and Physics* workshop held at the Institut Henri Poincaré in 2015. This volume covers a broad range of topics in mathematical physics, including noncommutative geometry, supergeometry, derived symplectic geometry, higher geometric quantization, intuitionistic quantum logic, problems with the continuum description of spacetime, twistor theory, loop quantum gravity, and geometry in string theory. It is addressed primarily to mathematical physicists and mathematicians, but also to historians and philosophers of these disciplines.

*Organized Time* is the first attempt to unite theories of harmony, rhythm and meter, and form under a common idea of structured time. Building off of recent

advances in music theory in essential subfields-rhythmic theory, tonal structure, and the theory of musical form--author Jason Yust demonstrates that tonal music exhibits similar hierarchical organization in each of these dimensions. Yust develops a network model for temporal structure with an application of mathematical graph theory, which leads ultimately to musical applications of a multi-dimensional polytope called the associahedron. A wealth of analytical examples includes not only the familiar tonal canon-J.S. Bach, Mozart, Schumann--but also lesser known masters of the musical Enlightenment such as C.P.E. and J.C. Bach, Boccherini, and Johann Gottlieb Graun. Yust's approach has wide-ranging ramifications across music theory, enabling new approaches to musical closure, hypermeter, formal function, syncopation, and rhythmic dissonance, as well as historical observations about the development of sonata form and the innovations of Haydn and Beethoven. Making a forceful argument for the independence of musical modalities and for a multivalent approach to music analysis, *Organized Time* establishes the aesthetic importance of structural disjunction, the conflict of structure in different modalities, in numerous analytical contexts.

At last, a friendly introduction to modern homotopy theory after Joyal and Lurie, reaching advanced tools and starting from scratch.

In this groundbreaking book, Tymoczko uses contemporary geometry to provide a new framework for thinking about music, one that emphasizes the commonalities among styles from Medieval polyphony to contemporary jazz.

The purpose of this book is to develop a generative theory of shape that has two properties we regard as fundamental to intelligence --(1) maximization of transfer: whenever possible, new structure should be described as the transfer of existing structure; and (2) maximization of recoverability: the generative operations in the theory must allow maximal inferentiability from data sets. We shall show that, if generativity satisfies these two basic criteria of intelligence, then it has a powerful mathematical structure and considerable applicability to the computational disciplines. The requirement of intelligence is particularly important in the generation of complex shape. There are plenty of theories of shape that make the generation of complex shape unintelligible. However, our theory takes the opposite direction: we are concerned with the conversion of complexity into understandability. In this, we will develop a mathematical theory of understandability. The issue of understandability comes down to the two basic principles of intelligence - maximization of transfer and maximization of recoverability. We shall show how to formulate these conditions group-theoretically. (1) Maximization of transfer will be formulated in terms of wreath products. Wreath products are groups in which there is an upper subgroup (which we will call a control group) that transfers a lower subgroup (which we will call a fiber group) onto copies of itself. (2) maximization of recoverability is insured when the control group is symmetry-breaking with respect to the fiber group.

This innovative monograph explores a new mathematical formalism in higher-order temporal logic for proving properties about the behavior of systems. Developed by the authors, the goal of this novel approach is to explain what occurs when multiple, distinct system components interact by using a category-theoretic description of behavior types based on sheaves. The authors demonstrate how to analyze the behaviors of elements in continuous and discrete dynamical systems so that each can be translated and compared to one another. Their temporal logic is also flexible enough that it can serve as a framework for other logics that work with similar models. The book begins with a discussion of behavior types, interval domains, and translation invariance, which serves as the groundwork for temporal type theory. From there, the authors lay out the logical preliminaries they need for their temporal modalities and explain the soundness of those logical semantics. These results are then applied to hybrid dynamical systems, differential equations, and labeled transition systems. A case study involving aircraft separation within the National Airspace System is provided to illustrate temporal type theory in action. Researchers in computer science, logic, and mathematics interested in topos-theoretic and category-theory-friendly approaches to system behavior will find this monograph to be an important resource. It can also serve as a supplemental text for a specialized graduate topics course.

This book presents a deep spectrum of musical, mathematical, physical, and philosophical perspectives that have emerged in this field at the intersection of music and mathematics. In particular the contributed chapters introduce advanced techniques and concepts from modern mathematics and physics, deriving from successes in domains such as Topos theory and physical string theory. The authors include many of the leading researchers in this domain, and the book will be of value to researchers working in computational music, particularly in the areas of counterpoint, gesture, and Topos theory.

This book represents a new approach to musical creativity, dealing with the semiotics, mathematical principles, and software for creativity processes. After a thorough introduction, the book offers a first practical part with a detailed tutorial for students in composition and improvisation, using musical instruments and music software. The second, theoretical part deals with historical, actual, and new principles of creative processes in music, based on the results and methods developed in the first author's book *Topos of Music* and referring to semiotics, predicative objects, topos theory, and object-oriented concept architectures. The third part of the book details four case studies in musical creativity, including an analysis of the six variations of Beethoven's sonata op. 109, a discussion of the creative process in a CD coproduced in 2011 by the first and second authors, a recomposition of Boulez's "Structures pour deux pianos" using the Rubato software module BigBang developed by the third author, and the Escher theorem from mathematical gesture theory in music. This is both a textbook addressed to undergraduate and graduate students of music composition and improvisation, and also a state-of-the-art survey addressed to researchers in creativity studies and music technology. The book contains summaries and end-of-chapter questions, and the authors have used the book as the main reference to teach an

undergraduate creativity studies program and also to teach composition. The text is supported throughout with musical score examples.

This Volume II of the Proceedings of the Worldwide Music Conference 2021 continues the line of publications of the first volume in a highly interdisciplinary mode. This time, we offer eight chapters that provide the in-depth study of music in four large sub-fields: mathematics, language and theory of narrative, evolution and perception, and, finally, sociology. The first chapter, by Roman Ruditsa, is devoted to the study of structural pitch organization. This is based upon a formal logical interpretation of the idea of pitch. The chapter contains formal definitions of such objects as tones, intervals, and interval systems and a demonstration of the logical relationships that exist between them. The second chapter, in the same mathematical venue, by Celina Richter and Stefan E. Schmidt, revisits the millennial question of the essence of an interval, using highly advanced mathematical language, the categories of monoid and the algebraic theory of measurement. The next block is dedicated to language and narrative; the first chapter is by Vincent Meelberg. Here, the reader will find fascinating developments in the ongoing deliberations on this elusive category. The name of Trevor Rawbone, perhaps, does not need an introduction to those involved with cognitive studies of music. This time, his chapter deals with the idea of the language of musical thought, which shifts the traditional discussion of language into a very new dimension. Carlos Almada begins a new section in the book, the one dedicated to evolution and perception. He begins with Darwin and takes us through the exciting path of development of the science of evolution, which he masterfully connects to his model of derivative analysis of music. The question of psycho-physiological foundation of the ethnic hearing, raised in the chapter by Ila V. Toropova and Irina N. Simakova, is a difficult one. The idea of ethnic character of music had been a part of traditional musicology and usually was expressed in specific language of humanities. The chapter by Daniil Shutko on the theoretical ideas of the legendary professor of St. Petersburg conservatory, Dr. Tatiana Bershanskaya, was difficult to put into any category. Her concept of music was truly universal and interdisciplinary. At the same time, the concept and Shutkos description are as closely focused on music theory in a narrow and precise sense as possible. The art and culture of consumption of wine in correlation with the choice of music for listening is a theme for a true connoisseur. It becomes even more intriguing when the authors, Diego Perez-Fuertes, Emma Juaneda-Ayensa and Cristina Olarte-Pascual, add to the discussion the special circumstance of the pandemic and the way human spirit meets this challenge in the most graceful way.

With contributions by numerous experts

According to Grothendieck, the notion of topos is "the bed or deep river where come to be married geometry and algebra, topology and arithmetic, mathematical logic and category theory, the world of the continuous and that of discontinuous or discrete structures." It is what he had "conceived of most broad to perceive with finesse, by the same language rich of geometric resonances, an "essence" which is common to situations most distant from each other, coming from one region or another of the vast universe of mathematical things." The aim of this book is to present a theory and a number of techniques which allow to give substance to Grothendieck's vision by building on the notion of classifying topos educed by categorical logicians.

Mathematical theories (formalized within first-order logic) give rise to geometric objects

called sites; the passage from sites to their associated toposes embodies the passage from the logical presentation of theories to their mathematical content, i.e. from syntax to semantics. The essential ambiguity given by the fact that any topos is associated in general with an infinite number of theories or different sites allows to study the relations between different theories, and hence the theories themselves, by using toposes as 'bridges' between these different presentations. The expression or calculation of invariants of toposes in terms of the theories associated with them or their sites of definition generates a great number of results and notions varying according to the different types of presentation, giving rise to a veritable mathematical morphogenesis. This volume provides a series of tutorials on mathematical structures which recently have gained prominence in physics, ranging from quantum foundations, via quantum information, to quantum gravity. These include the theory of monoidal categories and corresponding graphical calculi, Girard's linear logic, Scott domains, lambda calculus and corresponding logics for typing, topos theory, and more general process structures. Most of these structures are very prominent in computer science; the chapters here are tailored towards an audience of physicists.

This is the first volume of the second edition of the now classic book "The Topos of Music". The author explains the theory's conceptual framework of denotators and forms, the classification of local and global musical objects, the mathematical models of harmony and counterpoint, and topologies for rhythm and motives.

The original edition of *The Geometry of Musical Rhythm* was the first book to provide a systematic and accessible computational geometric analysis of the musical rhythms of the world. It explained how the study of the mathematical properties of musical rhythm generates common mathematical problems that arise in a variety of seemingly disparate fields. The book also introduced the distance approach to phylogenetic analysis and illustrated its application to the study of musical rhythm. The new edition retains all of this, while also adding 100 pages, 93 figures, 225 new references, and six new chapters covering topics such as meter and metric complexity, rhythmic grouping, expressive timbre and timing in rhythmic performance, and evolution phylogenetic analysis of ancient Greek paeonic rhythms. In addition, further context is provided to give the reader a fuller and richer insight into the historical connections between music and mathematics.

This text is an upgraded extension of 'Geometrie der Tone', published in 1990. It reflects the dramatic progress of mathematical music theory and its implementation by information technology. The conceptual basis has been generalized to topos-theoretic foundations.

This book constitutes the thoroughly refereed proceedings of the 6th International Conference on Mathematics and Computation in Music, MCM 2017, held in Mexico City, Mexico, in June 2017. The 26 full papers and 2 short papers presented were carefully reviewed and selected from 40 submissions. The papers feature research that combines mathematics or computation with music theory, music analysis, composition, and performance. They are organized in topical sections on algebraic models, computer assisted performance, Fourier analysis, Gesture Theory, Graph Theory and Combinatorics, Machine Learning, and Probability and Statistics in Musical Analysis and Composition.

In this book, first published in 2003, categorical algebra is used to build a foundation for the study of geometry, analysis, and algebra.

Algebra and Tiling is a book about how to cover surfaces with shapes.

“Witty, compelling, and just plain fun to read . . .” —Evelyn Lamb, *Scientific American*

The Freakonomics of math—a math-world superstar unveils the hidden beauty and logic of the world and puts its power in our hands

The math we learn in school can seem like a dull set of rules, laid down by the ancients and not to be questioned. In *How Not to Be Wrong*, Jordan Ellenberg shows us how terribly limiting this view is: Math isn’t confined to abstract incidents that never occur in real life, but rather touches everything we do—the whole world is shot through with it. Math allows us to see the hidden structures underneath the messy and chaotic surface of our world. It’s a science of not being wrong, hammered out by centuries of hard work and argument. Armed with the tools of mathematics, we can see through to the true meaning of information we take for granted: How early should you get to the airport? What does “public opinion” really represent? Why do tall parents have shorter children? Who really won Florida in 2000? And how likely are you, really, to develop cancer? *How Not to Be Wrong* presents the surprising revelations behind all of these questions and many more, using the mathematician’s method of analyzing life and exposing the hard-won insights of the academic community to the layman—minus the jargon. Ellenberg chases mathematical threads through a vast range of time and space, from the everyday to the cosmic, encountering, among other things, baseball, Reaganomics, daring lottery schemes, Voltaire, the replicability crisis in psychology, Italian Renaissance painting, artificial languages, the development of non-Euclidean geometry, the coming obesity apocalypse, Antonin Scalia’s views on crime and punishment, the psychology of slime molds, what Facebook can and can’t figure out about you, and the existence of God. Ellenberg pulls from history as well as from the latest theoretical developments to provide those not trained in math with the knowledge they need. Math, as Ellenberg says, is “an atomic-powered prosthesis that you attach to your common sense, vastly multiplying its reach and strength.” With the tools of mathematics in hand, you can understand the world in a deeper, more meaningful way. *How Not to Be Wrong* will show you how.

The idea of this monograph is to present an overview of decisive theoretical, computational, technological, aesthetical, artistic, economical, and sociological directions to create future music. It features a unique insight into dominant scientific and artistic new directions, which are guaranteed by the authors’ prominent publications in books, software, musical, and dance productions. Applying recent research results from mathematical and computational music theory and software as well as new ideas of embodiment approaches and non-Western music cultures, this book presents new composition methods and technologies. Mathematical, computational, and semiotic models of artistic presence (imaginary time, gestural creativity) as well as strategies are also covered. This book will be of interest to composers, music technicians, and

organizers in the internet-based music industry, who are offered concrete conceptual architectures and tools for their future strategies in musical creativity and production.

This is the third volume of the second edition of the now classic book "The Topos of Music". The authors present gesture theory, including a gesture philosophy for music, the mathematics of gestures, concept architectures and software for musical gesture theory, the multiverse perspective which reveals the relationship between gesture theory and the string theory in theoretical physics, and applications of gesture theory to a number of musical themes, including counterpoint, modulation theory, free jazz, Hindustani music, and vocal gestures. Grothendieck's beautiful theory of schemes permeates modern algebraic geometry and underlies its applications to number theory, physics, and applied mathematics. This simple account of that theory emphasizes and explains the universal geometric concepts behind the definitions. In the book, concepts are illustrated with fundamental examples, and explicit calculations show how the constructions of scheme theory are carried out in practice.

From the first chapter through the last, readers eager to learn more about the connections between mathematics and music will find a comprehensive textbook designed to satisfy their natural curiosity.

Contains all the mathematics that computer scientists need to know in one place.

Since their discovery hundreds of years ago, people have been fascinated by the wondrous properties of Fibonacci numbers. Being of mathematical significance in their own right, Fibonacci numbers have had an impact on areas like art and architecture, and their traces can be found in nature and even the behavior of the stock market. Starting with the basic properties of Fibonacci numbers, the present book explores their relevance in number theory, the theory of continued fractions, geometry and approximation theory. Rather than giving a complete account of the subject, a few chosen examples are treated exhaustively. They not only reveal the bearing of Fibonacci numbers on mathematics, but also provide very readable marvels of mathematical reasoning. This book is the translation of the 6th Russian edition (the first edition appeared in the early fifties and became a standard source of information on the subject). A rigorous, axiomatically formulated presentation of the 'zero-square', or 'nilpotent' infinitesimal.

This textbook is a first introduction to mathematics for music theorists, covering basic topics such as sets and functions, universal properties, numbers and recursion, graphs, groups, rings, matrices and modules, continuity, calculus, and gestures. It approaches these abstract themes in a new way: Every concept or theorem is motivated and illustrated by examples from music theory (such as harmony, counterpoint, tuning), composition (e.g., classical combinatorics, dodecaphonic composition), and gestural performance. The book includes many illustrations, and exercises with solutions.

This is the second volume of the second edition of the now classic book "The Topos of Music". The author explains his theory of musical performance, developed in the language of differential geometry, introducing performance vector fields that generalize tempo and intonation. The author also shows how Rubato, a software platform for composition, analysis, and performance, allows an experimental evaluation of principles of expressive performance theories.

Now in paper for the first time, Bitter Music is a generous volume of writings by one of the twentieth century's great musical iconoclasts. Rejecting the equal temperament and concert

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traditions that have dominated western music, Harry Partch adopted the pure intervals of just intonation and devised a 43-tone-to-the-octave scale, which in turn forced him into inventing numerous musical instruments. His compositions realize his ideal of a corporeal music that unites music, dance, and theater. Winner of the ASCAP-Deems Taylor Award, *Bitter Music* includes two journals kept by Partch, one while wandering the West Coast during the Depression and the other while hiking the rugged northern California coastline. It also includes essays and discussions by Partch of his own compositions, as well as librettos and scenarios for six major narrative/dramatic compositions.

Focusing on topos theory's integration of geometric and logical ideas into the foundations of mathematics and theoretical computer science, this volume explores internal category theory, topologies and sheaves, geometric morphisms, and other subjects. 1977 edition.

This book constitutes the thoroughly refereed proceedings of the 7th International Conference on Mathematics and Computation in Music, MCM 2019, held in Madrid, Spain, in June 2019. The 22 full papers and 10 short papers presented were carefully reviewed and selected from 48 submissions. The papers feature research that combines mathematics or computation with music theory, music analysis, composition, and performance. They are organized in topical sections on algebraic and other abstract mathematical approaches to understanding musical objects; remanaging Riemann: mathematical music theory as “experimental philosophy”?; octave division; computer-based approaches to composition and score structuring; models for music cognition and beat tracking; pedagogy of mathematical music theory. The chapter “Distant Neighbors and Interscalar Contiguities” is available open access under a Creative Commons Attribution 4.0 International License via [link.springer.com](http://link.springer.com).

This is the fourth volume of the second edition of the now classic book “The Topos of Music”. The author presents appendices with background material on sound and auditory physiology; mathematical basics such as sets, relations, transformations, algebraic geometry, and categories; complements in physics, including a discussion on string theory; and tables with chord classes and modulation steps.

In Western Civilization Mathematics and Music have a long and interesting history in common, with several interactions, traditionally associated with the name of Pythagoras but also with a significant number of other mathematicians, like Leibniz, for instance. Mathematical models can be found for almost all levels of musical activities from composition to sound production by traditional instruments or by digital means. Modern music theory has been incorporating more and more mathematical content during the last decades. This book offers a journey into recent work relating music and mathematics. It contains a large variety of articles, covering the historical aspects, the influence of logic and mathematical thought in composition, perception and understanding of music and the computational aspects of musical sound processing. The authors illustrate the rich and deep interactions that exist between Mathematics and Music.

Free jazz, as performed by such artists as John Coltrane and Archie Shepp, is a creative, collaborative art form. This book examines free jazz and develops

geometric theories of gestures and distributed identities, also known as swarm intelligence.

Algebraic geometry is a fascinating branch of mathematics that combines methods from both, algebra and geometry. It transcends the limited scope of pure algebra by means of geometric construction principles. Moreover, Grothendieck's schemes invented in the late 1950s allowed the application of algebraic-geometric methods in fields that formerly seemed to be far away from geometry, like algebraic number theory. The new techniques paved the way to spectacular progress such as the proof of Fermat's Last Theorem by Wiles and Taylor. The scheme-theoretic approach to algebraic geometry is explained for non-experts. More advanced readers can use the book to broaden their view on the subject. A separate part deals with the necessary prerequisites from commutative algebra. On a whole, the book provides a very accessible and self-contained introduction to algebraic geometry, up to a quite advanced level. Every chapter of the book is preceded by a motivating introduction with an informal discussion of the contents. Typical examples and an abundance of exercises illustrate each section. This way the book is an excellent solution for learning by yourself or for complementing knowledge that is already present. It can equally be used as a convenient source for courses and seminars or as supplemental literature.

Since precious few architectural drawings and no theoretical treatises on architecture remain from the premodern Islamic world, the Timurid pattern scroll in the collection of the Topkapi Palace Museum Library is an exceedingly rich and valuable source of information. In the course of her in-depth analysis of this scroll dating from the late fifteenth or early sixteenth century, Gülru Necipoğlu throws new light on the conceptualization, recording, and transmission of architectural design in the Islamic world between the tenth and sixteenth centuries. Her text has particularly far-reaching implications for recent discussions on vision, subjectivity, and the semiotics of abstract representation. She also compares the Islamic understanding of geometry with that found in medieval Western art, making this book particularly valuable for all historians and critics of architecture. The scroll, with its 114 individual geometric patterns for wall surfaces and vaulting, is reproduced entirely in color in this elegant, large-format volume. An extensive catalogue includes illustrations showing the underlying geometries (in the form of incised "dead" drawings) from which the individual patterns are generated. An essay by Mohammad al-Asad discusses the geometry of the muqarnas and demonstrates by means of CAD drawings how one of the scroll's patterns could be used to design a three-dimensional vault.

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Category theory is unmatched in its ability to organize and layer abstractions and to find commonalities between structures of all sorts. No longer the exclusive

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preserve of pure mathematicians, it is now proving itself to be a powerful tool in science, informatics, and industry. By facilitating communication between communities and building rigorous bridges between disparate worlds, applied category theory has the potential to be a major organizing force. This book offers a self-contained tour of applied category theory. Each chapter follows a single thread motivated by a real-world application and discussed with category-theoretic tools. We see data migration as an adjoint functor, electrical circuits in terms of monoidal categories and operads, and collaborative design via enriched profunctors. All the relevant category theory, from simple to sophisticated, is introduced in an accessible way with many examples and exercises, making this an ideal guide even for those without experience of university-level mathematics.

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