Simplicial Calculus With Geometric Algebra

Noncommutative Geometry is one of the most deep and vital research subjects of present-day Mathematics. Its development, mainly due to Alain Connes, is providing an increasing number of applications and deeper insights for instance in Foliations, K-Theory, Index Theory, Number Theory but also in Quantum Physics of elementary particles. The purpose of the Summer School in Martina Franca was to offer a fresh invitation to the subject and closely related topics; the contributions in this volume include the four main lectures, cover advanced developments and are delivered by prominent specialists.
The key idea in geometric group theory is to study infinite groups by endowing them with a metric and treating them as geometric spaces. This applies to many groups naturally appearing in topology, geometry, and algebra, such as fundamental groups of manifolds, groups of matrices with integer coefficients, etc. The primary focus of this book is to cover the foundations of geometric group theory, including coarse topology, ultralimits and asymptotic cones, hyperbolic groups, isoperimetric inequalities, growth of groups, amenability, Kazhdan's Property (T) and the Haagerup property, as well as their characterizations in terms of group actions on median spaces and spaces with walls. The book contains proofs of several fundamental results of geometric group theory, such as Gromov's theorem on groups of polynomial growth, Tits's alternative, Stallings's theorem on ends of groups, Dunwoody's accessibility theorem, the Mostow Rigidity Theorem, and quasiisometric rigidity theorems of Tukia and Schwartz. This is the first book in which geometric group theory is presented in a form accessible to advanced graduate students and young research mathematicians. It fills a big gap in the literature and will be used by researchers in geometric group theory and its applications.
In recent years, many students have been introduced to topology in high school mathematics. Having met the Mobius band, the seven bridges of Konigsberg, Euler's polyhedron formula, and knots, the student is led to expect that these picturesque ideas will come to full flower in university topology courses. What a disappointment "undergraduate topology" proves to be! In most institutions it is either a service course for analysts, on abstract spaces, or else an introduction to homological algebra in which the only geometric activity is the completion of commutative diagrams. Pictures are kept to a minimum, and at the end the student still does nr~ understand the simplest topological facts, such as the rcason why knots exist. In my opinion, a well-balanced introduction to topology should stress its intuitive geometric aspect, while admitting the legitimate interest that analysts and algebraists have in the subject. At any rate, this is the aim of the present book. In support of this view, I have followed the historical development where practicable, since it clearly shows the influence of geometric thought at all stages. This is not to claim that topology received its main impetus from geometric recreations like the seven bridges; rather, it resulted from the l'isualization of problems from other parts of mathematics-complex analysis (Riemann), mechanics (Poincare), and group theory (Dehn). It is these connec tions to other parts of mathematics which make topology an important as well as a beautiful subject.
Geometric algebra is a powerful mathematical language with applications across a range of subjects in physics and engineering. This book is a complete guide to the current state of the subject with early chapters providing a self-contained introduction to geometric algebra. Topics covered include new techniques for handling rotations in arbitrary dimensions, and the links between rotations, bivectors and the structure of the Lie groups. Following chapters extend the concept of a complex analytic function theory to arbitrary dimensions, with applications in quantum theory and electromagnetism. Later chapters cover advanced topics such as non-Euclidean geometry, quantum entanglement, and gauge theories. Applications such as black holes and cosmic strings are also explored. It can be used as a graduate text for courses on the physical applications of geometric algebra and is also suitable for researchers working in the fields of relativity and quantum theory.
Matrix algebra has been called "the arithmetic of higher mathematics" [Be]. We think the basis for a better arithmetic has long been available, but its versatility has hardly been appreciated, and it has not yet been integrated into the mainstream of mathematics. We refer to the system commonly called 'Clifford Algebra', though we prefer the name 'Geometric Algebm' suggested by Clifford himself. Many distinct algebraic systems have been adapted or developed to express geometric relations and describe geometric structures. Especially notable are those algebras which have been used for this purpose in physics, in particular, the system of complex numbers, the quatemions, matrix algebra, vector, tensor and spinor algebras and the algebra of differential forms. Each of these geometric algebras has some significant advantage over the others in certain applications, so no one of them provides an adequate algebraic structure for all purposes of geometry and physics. At the same time, the algebras overlap considerably, so they provide several different mathematical representations for individual geometrical or physical ideas.
This book develops abstract homotopy theory from the categorical perspective with a particular focus on examples. Part I discusses two competing perspectives by which one typically first encounters homotopy (co)limits: either as derived functors definable when the appropriate diagram categories admit a compatible model structure, or through particular formulae that give the right notion in certain examples. Emily Riehl unifies these seemingly rival perspectives and demonstrates that model structures on diagram categories are irrelevant. Homotopy (co)limits are explained to be a special case of weighted (co)limits, a foundational topic in enriched category theory. In Part II, Riehl further examines this topic, separating categorical arguments from homotopical ones. Part III treats the most ubiquitous axiomatic framework for homotopy theory - Quillen's model categories. Here, Riehl simplifies familiar model categorical lemmas and definitions by focusing on weak factorization systems. Part IV introduces quasi-categories and homotopy coherence.
This proceedings reports on some of the most recent advances on the interaction between Differential Geometry and Theoretical Physics, a very active and exciting area of contemporary research. The papers are grouped into the following four broad categories: Geometric Methods, Noncommutative Geometry, Quantum Gravity and Topological Quantum

Field Theory. A few of the topics covered are Chern-Simons Theory and Generalizations, Knot Invariants, Models of 2D Gravity, Quantum Groups and Strings on Black Holes.

The uniqueness of this text in combining geometric topology and differential geometry lies in its unifying thread: the notion of a surface. With numerous illustrations, exercises and examples, the student comes to understand the relationship of the modern abstract approach to geometric intuition. The text is kept at a concrete level, avoiding unnecessary abstractions, yet never sacrificing mathematical rigor. The book includes topics not usually found in a single book at this level.

This volume offers a comprehensive approach to the theoretical, applied and symbolic computational aspects of the subject. Excellent for self-study, leading experts in the field have written on the of topics mentioned above, using an easy approach with efficient geometric language for non-specialists.

* Stanley represents a broad perspective with respect to two significant topics from Combinatorial Commutative Algebra: 1) The theory of invariants of a torus acting linearly on a polynomial ring, and 2) The face ring of a simplicial complex * In this new edition, the author further develops some interesting properties of face rings with application to combinatorics

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.

This volume is an outgrowth of the 1995 Summer School on Theoretical Physics of the Canadian Association of Physicists (CAP), held in Banff, Alberta, in the Canadian Rockies, from July 30 to August 12,1995. The chapters, based on lectures given at the School, are designed to be tutorial in nature, and many include exercises to assist the learning process. Most lecturers gave three or four fifty-minute lectures aimed at relative novices in the field. More emphasis is therefore placed on pedagogy and establishing comprehension than on erudition and superior scholarship. Of course, new and exciting results are presented in applications of Clifford algebras, but in a coherent and user-friendly way to the nonspecialist. The subject area of the volume is Clifford algebra and its applications. Through the geometric language of the Clifford-algebra approach, many concepts in physics are clarified, united, and extended in new and sometimes surprising directions. In particular, the approach eliminates the formal gaps that traditionally separate clas sical, quantum, and relativistic physics. It thereby makes the study of physics more efficient and the research more penetrating, and it suggests resolutions to a major physics problem of the twentieth century, namely how to unite quantum theory and gravity. The term "geometric algebra" was used by Clifford himself, and David Hestenes has suggested its use in order to emphasize its wide applicability, and b& cause the developments by Clifford were themselves based heavily on previous work by Grassmann, Hamilton, Rodrigues, Gauss, and others.

An introductory textbook suitable for use in a course or for self-study, featuring broad coverage of the subject and a readable exposition, with many examples and exercises.

This set of notes is an activity-oriented introduction to linear and multilinear algebra. The great majority of the most elementary results in these subjects are straightforward and can be verified by the thoughtful student. Indeed, that is the main point of these notes — to convince the beginner that the subject is accessible. In the material that follows there are numerous indicators that suggest activity on the part of the reader: words such as 'proposition', 'example', 'theorem', 'exercise', and 'corollary', if not followed by a proof (and proofs here are very rare) or a reference to a proof, are invitations to verify the assertions made.These notes are intended to accompany an (academic) year-long course at the advanced undergraduate or beginning graduate level. (With judicious pruning most of the material can be covered in a two-term sequence.) The text is also suitable for a lecture-style class, the instructor proving some of the results while leaving others as exercises for the students.This book has tried to keep the facts about vector spaces and those about inner product spaces separate. Many beginning linear algebra texts conflate the material on these two vastly different subjects.

The goal of the Volume I Geometric Algebra for Computer Vision, Graphics and Neural Computing is to present a unified mathematical treatment of diverse problems in the general domain of artificial intelligence and associated fields using Clifford, or geometric, algebra. Geometric algebra provides a rich and general mathematical framework for Geometric Cybernetics in order to develop solutions, concepts and computer algorithms without losing geometric insight of the problem in question. Current mathematical subjects can be treated in an unified manner without abandoning the mathematical system of geometric algebra for instance: multilinear algebra, projective and affine geometry, calculus on manifolds, Riemann geometry, the representation of Lie algebras and Lie groups using bivector algebras and conformal geometry. By treating a wide spectrum of problems in a common language, this Volume I offers both new insights and new solutions that should be useful to scientists, and engineers working in different areas related with the development and building of intelligent machines. Each chapter is written in accessible terms accompanied by numerous examples, figures and a complementary appendix on Clifford algebras, all to clarify the theory and the crucial aspects of the application of geometric algebra to problems in graphics engineering, image processing, pattern recognition, computer vision, machine learning, neural computing and cognitive systems.

Since the beginning of the modern era of algebraic topology, simplicial methods have been used systematically and effectively for both computation and basic theory. With the development of Quillen's concept of a closed model category and, in particular, a simplicial model category, this collection of methods has become the primary way to describe non-abelian homological algebra and to address homotopy-theoretical issues in a variety of fields, including algebraic K-theory. This book supplies a modern exposition of these ideas, emphasizing model category theoretical techniques. Discussed here are the homotopy theory of simplicial sets, and other basic topics such as simplicial groups, Postnikov towers, and bisimplicial sets. The more advanced material includes homotopy limits and colimits, localization with respect to a map and with respect to a homology theory, cosimplicial spaces, and homotopy coherence. Interspersed throughout are many results and ideas well-known to experts, but uncollected in the literature. Intended for second-year graduate students and beyond, this book introduces many of the basic tools of modern homotopy theory. An extensive background in topology is not assumed.

The intention of this collection agrees with the purposes of the homonymous mini-symposium (MS) at ICIAM-2019, which were to overview the essentials of geometric calculus (GC) formalism, to report on state-of-the-art applications showcasing its advantages and to explore the bearing of GC in novel approaches to deep learning. The first three contributions, which correspond to lectures at the MS, offer perspectives on recent advances in the application GC in the areas of robotics, molecular geometry, and medical imaging. The next three, especially invited, hone the expressiveness of GC in orientation measurements under different metrics, the treatment of contact elements, and the investigation of efficient computational methodologies. The last two, which also correspond to lectures at the MS, deal with two aspects of deep learning: a presentation of a concrete quaternionic convolutional neural network layer for image classification that features contrast invariance and a general overview of automatic learning aimed at steering the development of neural networks whose units process elements of a suitable algebra, such as a geometric algebra. The book fits, broadly speaking, within the realm of mathematical engineering, and consequently, it is intended for a wide spectrum of research profiles. In particular, it should bring inspiration and guidance to those looking for materials and problems that bridge GC with applications of great current interest, including the auspicious field of GC-based deep neural networks.

This ENCYCLOPAEDIA OF MATHEMATICS aims to be a reference work for all parts of mathe matics. It is a translation with updates and editorial comments of the Soviet Mathematical Encyclopaedia published by 'Soviet Encyclopaedia Publishing House' in five volumes in 1977-1985. The annotated translation consists of ten volumes including a special index volume. There are three kinds of articles in this ENCYCLOPAEDIA. First of all there are survey-type articles dealing with the various main directions in mathematics (where a rather fine subdivi sion has been used). The main requirement for these articles has been that they should give a reasonably complete up-to-date account of the current state of affairs in these areas and that they should be maximally accessible. On the whole, these articles should be understandable to mathematics students in their first specialization years, to graduates from other mathematical areas and, depending on the specific subject, to specialists in other domains of science, en gineers and teachers of mathematics. These articles treat their material at a fairly general level and aim to give an idea of the kind of problems, techniques and concepts involved in the area in question. They also contain background and motivation rather than precise statements of precise theorems with detailed definitions and technical details on how to carry out proofs and constructions. The second kind of article, of medium length, contains more detailed concrete problems, results and techniques.

The first book of its kind, New Foundations in Mathematics: The Geometric Concept of Number uses geometric algebra to present an innovative approach to elementary and advanced mathematics. Geometric algebra offers a simple and robust means of expressing a wide range of ideas in mathematics, physics, and engineering. In particular, geometric algebra extends the real number system to include the concept of direction, which underpins much of modern mathematics and physics. Much of the material presented has been developed from undergraduate courses taught by the author over the years in linear algebra, theory of numbers, advanced calculus and vector calculus, numerical analysis, modern abstract algebra, and differential geometry. The principal aim of this book is to present these ideas in a freshly coherent and accessible manner. New Foundations in Mathematics will be of interest to undergraduate and graduate students of mathematics and physics who are looking for a unified treatment of many important geometric ideas arising in these subjects at all levels. The material can also serve as a supplemental textbook in some or all of the areas mentioned above and as a reference book for professionals who apply mathematics to engineering and computational areas of mathematics and physics.

Quarternionic calculus covers a branch of mathematics which uses computational techniques to help solve problems from a wide variety of physical systems which are mathematically modelled in 3, 4 or more dimensions. Examples of the application areas include thermodynamics, hydrodynamics, geophysics and structural mechanics. Focusing on the Clifford algebra approach the authors have drawn together the research into quarternionic calculus to provide the non-expert or research student with an accessible introduction to the subject. This book fills the gap between the theoretical representations and the requirements of the user.

The main purpose of the present work is to present to the reader a particularly nice category for the study of homotopy, namely the homo topic category (IV). This category is, in fact, - according to Chapter VII and a well-known theorem of J. H. C. WHITEHEAD - equivalent to the category of CW-complexes modulo homotopy, i.e. the category whose objects are spaces of the homotopy type of a CW-complex and whose morphisms are homotopy classes of continuous mappings between such spaces. It is also equivalent (I, 1.3) to a category of fractions of the category of topological spaces modulo homotopy, and to the category of Kan complexes modulo homotopy (IV). In order to define our homotopic category, it appears useful to follow as closely as possible methods which have proved efficacious in homo logical algebra. Our category is thus the" topological" analogue of the derived category of an abelian category (VERDIER). The algebraic machinery upon which this work is essentially based includes the usual grounding in category theory - summarized in the Dictionary - and the theory of categories of fractions which forms the subject of the first chapter of the book. The merely topological machinery reduces to a few properties of Kelley spaces (Chapters I and III). The starting point of our study is the category ,10 Iff of simplicial sets (C.S.S. complexes or semi-simplicial sets in a former terminology).

Developed from a first-year graduate course in algebraic topology, this text is an informal introduction to some of the main ideas of contemporary homotopy and cohomology theory. The materials are structured around four core areas: de Rham theory, the Cech-de Rham complex, spectral sequences, and characteristic classes. By using the de Rham theory of differential forms as a prototype of cohomology, the machineries of algebraic topology are made easier to assimilate. With its stress on concreteness, motivation, and readability, this book is equally suitable for self-study and as a one-semester course in topology.

Derived algebraic geometry is a far-reaching generalization of algebraic geometry. It has found numerous applications in various parts of mathematics, most prominently in representation theory. This volume develops the theory of ind-coherent sheaves in the context of derived algebraic geometry. Ind-coherent sheaves are a “renormalization” of quasi-coherent sheaves and provide a natural setting for Grothendieck-Serre duality as well as geometric incarnations of numerous categories of interest in representation theory. This volume consists of three parts and an appendix. The first part is a survey of homotopical algebra in the setting of $infty$-categories and the basics of derived algebraic geometry. The second part builds the theory of ind-coherent sheaves as a functor out of the category of correspondences and studies the relationship between ind-coherent and quasi-coherent sheaves. The third part sets up the general machinery of the $mathrm{(}infty, 2mathrm{)}$-category of correspondences needed for the second part. The category of correspondences, via the theory developed in the third part, provides a general framework for Grothendieck's six-functor formalism. The appendix provides the necessary background on $mathrm{(}infty, 2mathrm{)}$-categories needed for the third part.

This highly practical Guide to Geometric Algebra in Practice reviews algebraic techniques for geometrical problems in computer science and engineering, and the relationships between them. The topics covered range from powerful new theoretical developments, to successful applications, and the development of new software and hardware tools. Topics and features: provides hands-on review exercises throughout the book, together with helpful chapter summaries; presents a concise introductory tutorial to conformal geometric algebra (CGA) in the appendices; examines the application of CGA for the description of rigid body motion, interpolation and tracking, and image processing; reviews the employment of GA in theorem proving and combinatorics; discusses the geometric algebra of lines, lower-dimensional algebras, and other alternatives to 5-dimensional CGA; proposes applications of coordinate-free methods of GA for differential geometry.

Until recently, almost all of the interactions between objects in virtual 3D worlds have been based on calculations performed using linear algebra. Linear algebra relies heavily on coordinates, however, which can make many geometric programming tasks very specific and complex-often a lot of effort is required to bring about even modest performance enhancements. Although linear algebra is an efficient way to specify low-level computations, it is not a suitable high-level language for geometric programming. Geometric Algebra for Computer Science presents a compelling alternative to the limitations of linear algebra. Geometric algebra, or GA, is a compact, time-effective, and performance-enhancing way to represent the geometry of 3D objects in computer programs. In this book you will find an introduction to GA that will give you a strong grasp of its relationship to linear algebra and its significance for your work. You will learn how to use GA to represent objects and perform geometric operations on them. And you will begin mastering proven techniques for making GA an integral part of your applications in a way that simplifies your code without slowing it down. * The first book on Geometric Algebra for programmers in computer graphics and entertainment computing * Written by leaders in the field providing essential information on this new technique for 3D graphics * This full colour book includes a website with GAViewer, a program to experiment with GA

This book is part of Algebra and Geometry, a subject within the SCIENCES collection published by ISTE and Wiley, and the second of three volumes specifically focusing on algebra and its applications. Algebra and Applications 2 centers on the increasing role played by combinatorial algebra and Hopf algebras, including an overview of the basic theories on non-associative algebras, operads and (combinatorial) Hopf algebras. The chapters are written by recognized experts in the field, providing insight into new trends, as well as a comprehensive introduction to the theory. The book incorporates self-contained surveys with the main results, applications and perspectives. The chapters in this volume cover a wide variety of algebraic structures and their related topics. Alongside the focal topic of combinatorial algebra and Hopf algebras, non-associative algebraic structures in iterated integrals, chronological calculus, differential equations, numerical methods, control theory, non-commutative symmetric functions, Lie series, descent algebras, Butcher groups, chronological algebras, Magnus expansions and Rota–Baxter algebras are explored. Algebra and Applications 2 is of great interest to graduate students and researchers. Each chapter combines some of the features of both a graduate level textbook and of research level surveys.

This is the first book on a newly emerging field of discrete differential geometry providing an excellent way to access this exciting area. It provides discrete equivalents of the geometric notions and methods of differential geometry, such as notions of curvature and integrability for polyhedral surfaces. The carefully edited collection of essays gives a lively, multi-facetted introduction to this emerging field.

This textbook for the undergraduate vector calculus course presents a unified treatment of vector and geometric calculus. It is a sequel to the text Linear and Geometric Algebra by the same author. That text is a prerequisite for this one. Linear algebra and vector calculus have provided the basic vocabulary of mathematics in dimensions greater than one for the past one hundred years. Just as geometric algebra generalizes linear algebra in powerful ways, geometric calculus generalizes vector calculus in powerful ways. Traditional vector calculus topics are covered, as they must be, since readers will encounter them in other texts and out in the world. Differential geometry is used today in many disciplines. A final chapter is devoted to it. Visit the book's web site: http: //faculty.luther.edu/ macdonal/vagc to download the table of contents, preface, and index. This is a third printing, corrected and slightly revised. From a review of Linear and Geometric Algebra Alan Macdonald's text is an excellent resource if you are just beginning the study of geometric algebra and would like to learn or review traditional linear algebra in the process. The clarity and evenness of the writing, as well as the originality of presentation that is evident throughout this text, suggest that the author has been successful as a mathematics teacher in the undergraduate classroom. This carefully crafted text is ideal for anyone learning geometric algebra in relative isolation, which I suspect will be the case for many readers. -- Jeffrey Dunham, William R. Kenan Jr. Professor of Natural Sciences, Middlebury College

Simplicial sets are discrete analogs of topological spaces. They have played a central role in algebraic topology ever since their introduction in the late 1940s, and they also play an important role in other areas such as geometric topology and algebraic geometry. On a formal level, the homotopy theory of simplicial sets is equivalent to the homotopy theory of topological spaces. In view of this equivalence, one can apply discrete, algebraic techniques to perform basic topological constructions. These techniques are particularly appropriate in the theory of localization and completion of topological spaces, which was developed in the early 1970s. Since it was first published in 1967, Simplicial Objects in Algebraic Topology has been the standard reference for the theory of simplicial sets and their relationship to the homotopy theory of topological spaces. J. Peter May gives a lucid account of the basic homotopy theory of simplicial sets, together with the equivalence of homotopy theories alluded to above. The central theme is the simplicial approach to the theory of fibrations and bundles, and especially the algebraization of fibration and bundle theory in terms of "twisted Cartesian products." The Serre spectral sequence is described in terms of this algebraization. Other topics treated in detail include Eilenberg-MacLane complexes, Postnikov systems, simplicial groups, classifying complexes, simplicial Abelian groups, and acyclic models. "Simplicial Objects in Algebraic Topology presents much of the elementary material of algebraic topology from the semi-simplicial viewpoint. It should prove very valuable to anyone wishing to learn semi-simplicial topology. [May] has included detailed proofs, and he has succeeded very well in the task of organizing a large body of previously scattered material."—Mathematical Review

Advances in Chemical Physics covers recent advances at the cutting edge of research relative to chemical physics. The series, Advances in Chemical Physics, provides a forum for critical, authoritative evaluations of advances in every area of the discipline.

This volume contains selected papers presented at the Second Workshop on Clifford Algebras and their Applications in Mathematical Physics. These papers range from various algebraic and analytic aspects of Clifford algebras to applications in, for example, gauge fields, relativity theory, supersymmetry and supergravity, and condensed phase physics. Included is a biography and list of publications of Mário Schenberg, who, next to Marcel Riesz, has made valuable contributions to these topics. This volume will be of interest to mathematicians working in the fields of algebra, geometry or special functions, to physicists working on quantum mechanics or supersymmetry, and to historians of mathematical physics.

Elements of Algebraic Topology provides the most concrete approach to the subject. With coverage of homology and cohomology theory, universal coefficient theorems, Kunneth theorem, duality in manifolds, and applications to classical theorems of point-set topology, this book is perfect for comunicating complex topics and the fun nature of algebraic topology for beginners.

Table of contents

Clifford Algebras and their Applications in Mathematical PhysicsSpringer Science & Business Media

" . . . that famous pedagogical method whereby one begins with the general and proceeds to the particular only after the student is too confused to understand even that anymore. " Michael Spivak This text was written as an antidote to topology courses such as Spivak It is meant to provide the student with an experience in geomet describes. ric topology. Traditionally, the only topology an undergraduate might see is point-set topology at a fairly abstract level. The next course the average stu dent would take would be a graduate course in algebraic topology, and such courses are commonly very homological in nature, providing quick access to current research, but not developing any intuition or geometric sense. I have tried in this text to provide the undergraduate with a pragmatic introduction to the field, including a sampling from point-set, geometric, and algebraic topology, and trying not to include anything that the student cannot immediately experience. The exercises are to be considered as an in tegral part of the text and, ideally, should be addressed when they are met, rather than at the end of a block of material. Many of them are quite easy and are intended to give the student practice working with the definitions and digesting the current topic before proceeding. The appendix provides a brief survey of the group theory needed.

Quaternion and Clifford Fourier Transforms describes the development of quaternion and Clifford Fourier transforms in Clifford (geometric) algebra over the last 30 years. It is the first comprehensive, self-contained book covering this vibrant new area of pure and applied mathematics in depth. The book begins with a historic overview, followed by chapters on Clifford and quaternion algebra and geometric (vector) differential calculus (part of Clifford analysis). The core of the book consists of one chapter on quaternion Fourier transforms and one on Clifford Fourier transforms. These core chapters and their sections on more special topics are reasonably self-contained, so that readers already somewhat familiar with quaternions and Clifford algebra will hopefully be able to begin reading directly in the chapter and section of their particular interest, without frequently needing to skip back and forth. The topics covered are of fundamental interest to pure and applied mathematicians, physicists, and engineers (signal and color image processing, electrical engineering, computer science, computer graphics, artificial intelligence, geographic information science, aero-space engineering, navigation, etc.). Features Intuitive real geometric approach to higher-dimensional Fourier transformations A comprehensive reference, suitable for graduate students and researchers Includes detailed definitions, properties, and many full step-by-step proofs Many figures and tables, a comprehensive biography, and a detailed index make it easy to locate information

This monograph-like anthology introduces the concepts and framework of Clifford algebra. It provides a rich source of examples of how to work with this formalism. Clifford or geometric algebra shows strong unifying aspects and turned out in the 1960s to be a most adequate formalism for describing different geometry-related algebraic systems as specializations of one "mother algebra" in various subfields of physics and engineering. Recent work shows that Clifford algebra provides a universal and powerful algebraic framework for an elegant and coherent representation of various problems occurring in computer science, signal processing, neural computing, image processing, pattern recognition, computer vision, and robotics.