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44C - STEVENS JAYLEN

This book reproduces a course of ten lectures given by the author, Karl W. Gruenberg, at the NSF Regional Conference at the University of Wisconsin-Parkside in July 1974. The aim of the lectures was twofold: to show group theorists how the presentation theory of finite groups can nowadays be successfully approached with the help of integral representation theory, and to persuade ring theorists that here was an area of group theory well suited to applications of integral representation theory. The course was constructed so that only a modicum of either group theory or module theory would be presupposed of the audience. He has also drawn on lectures that he gave at the Australian Summer Research Institute held at the University of Sydney in 1971 and at the Australian National University at Canberra in 1974.

'We explore widely in the valley of ordinary representations, and we take the reader over the mountain pass leading to the valley of modular representations, to a point from which (s)he can survey this valley, but we do not attempt to widely explore it. We hope the reader will be sufficiently fascinated by the scenery to further explore both valleys on his/her own' - from the Preface. Representation theory plays important roles in geometry, algebra, analysis, and mathematical physics. In particular, it has been one of the great tools in the study and classification of finite groups. The theory contains some particularly beautiful results: Frobenius' theorem, Burnside's theorem, Artin's theorem, Brauer's theorem - all of which are covered in this textbook. Some seem uninspiring at first but prove to be quite useful. Others are clearly deep from the outset.And when a group (finite or otherwise) acts on something else (as a set of symmetries, for example), one ends up with a natural representation of the group. This book is an introduction to the representation theory of finite groups from an algebraic point of view, regarding representations as modules over the group algebra. The approach is to develop the requisite algebra in reasonable generality and then to specialize it to the case of group representations. Methods and results particular to group representations, such as characters and induced representations, are developed in depth. Arithmetic comes into play when considering the field of definition of a representation, especially for subfields of the complex numbers.The book has an extensive development of the semisimple case, where the characteristic of the field is zero or is prime to the order of the group, and builds the foundations of the modular case, where the characteristic of the field divides the order of the group. The book assumes only the material of a standard graduate course in algebra. It is suitable as a text for a year-long graduate course. The subject is of interest to students of algebra, number theory and algebraic geometry. The systematic treatment presented here makes the book also valuable as a reference.

There are two approaches to projective representation theory of symmetric and alternating groups, which are powerful enough to work for modular representations. One is based on Sergeev duality, which connects projective representation theory of the symmetric group and representation theory of the algebraic supergroup $Q(n)$ via appropriate Schur (super)algebras and Schur functors. The second approach follows the work of Grojnowski for classical affine and cyclotomic Hecke algebras and connects projective representation theory of symmetric groups in characteristic p to the crystal graph of the basic module of the twisted affine Kac-Moody algebra of type $A_{p-1}^{(2)}$. The goal of this work is to connect the two approaches mentioned above and to obtain new branching results for projective representations of symmetric groups.

The representation theory of symmetric groups is one of the most beautiful, popular and important parts of algebra, with many deep relations to other areas of mathematics such as combinatories, Lie theory and algebraic geometry. Kleshchev describes a new approach to the subject, based on the recent work of Lascoux, Leclerc, Thibon, Ariki, Grojnowski and Brundan, as well as his own. Much of this work has previously appeared only in the research literature. However to make it accessible to graduate students, the theory is developed from scratch, the only prerequisite being a standard course in abstract algebra. For the sake of transparency, Kleshchev concentrates on symmetric and spin-symmetric groups, though methods he develops are quite general and apply to a number of related objects. In sum, this unique book will be welcomed by graduate students and researchers as a modern account of the subject.

Representations of Finite Groups provides an account of the fundamentals of ordinary and modular representations. This book discusses the fundamental theory of complex representations of finite groups. Organized into five chapters, this book begins with an overview of the basic facts about rings and modules. This text then provides the theory of algebras, including theories of simple algebras, Frobenius algebras, crossed products, and Schur indices with representation-theoretic versions of them. Other chapters include a survey of the fundamental theory of modular representations, with emphasis on Brauer characters. This book discusses as well the module-theoretic representation theory due to Green and includes some topics such as Burry–Carlson's theorem and Scott modules. The final chapter deals with the fundamental results of Brauer on blocks and Fong's theory of covering, and includes some approaches to them. This book is a valuable resource for readers who are interested in the various approaches to the study of the representations of groups.

Very roughly speaking, representation theory studies symmetry in linear spaces. It is a beautiful mathematical subject which has many applications, ranging from number theory and combinatorics to geometry, probability theory, quantum mechanics, and quantum field theory. The goal of this book is to give a ``holistic'' introduction to representation theory, presenting it as a unified subject which studies representations of associative algebras and treating the representation theories of groups, Lie algebras, and quivers as special cases. Using this approach, the book covers a number of standard topics in the representation theories of these structures. Theoretical material in the book is supplemented by many problems and exercises which touch upon a lot of additional topics; the more difficult exercises are provided with hints. The book is designed as a textbook for advanced undergraduate and beginning graduate students. It should be accessible to students with a strong background in linear algebra and a basic knowledge of abstract algebra.

This monograph adopts an operational and functional analytic approach to the following problem: given a short exact sequence (group extension) 1 → N → G → H → 1 of finite groups, describe the irreducible representations of G by means of the structure of the group extension. This problem has attracted many mathematicians, including I. Schur, A.H. Clifford, and G. Mackey and, more recently, M. Isaacs, B. Huppert, Y.G. Berkovich & E.M. Zhmud, and J.M.G. Fell & R.S. Doran. The main topics are, on the one hand, Clifford Theory and the Little Group Method (of Mackey and Wigner) for induced representations, and, on the other hand, Kirillov's Orbit Method (for step-2 nilpotent groups of odd order) which establishes a natural and powerful correspondence between Lie rings and nilpotent groups. As an application, a detailed description is given of the representation theory of the alternating groups, of metacyclic, quaternionic, dihedral groups, and of the (finite) Heisenberg group. The Little Group Method may be applied if and only if a suitable unitary 2-cocycle (the Mackey obstruction) is trivial. To overcome this obstacle, (unitary) projective representations are introduced and corresponding Mackey and Clifford theories are developed. The commutant of an induced representation and the relative Hecke algebra is also examined. Finally, there is a comprehensive exposition of the theory of projective representations for finite Abelian groups which is applied to obtain a complete description of the irreducible representations of finite metabelian groups of odd order.

Applications of Finite Groups focuses on the applications of finite groups to problems of physics, including representation theory, crystals, wave equations, and nuclear and molecular structures. The book first elaborates on matrices, groups, and representations. Topics include abstract properties, applications, matrix groups, key theorem of representation theory, properties of character tables, simply reducible groups, tensors and invariants, and representations generated by functions. The text then examines applications and subgroups and representations, as well as subduced and induced representations, fermion annihilation and creation operators, crystallographic point groups, proportionality tensors in crystals, and nonrelativistic wave equations. The publication takes a look at space group representations and energy bands, symmetric groups, and applications. Topics include molecular and nuclear structures, multiplet splitting in crystalline electric fields, construction of irreducible representations of the symmetric groups, and reality of representations. The manuscript is a dependable source of data for physicists and researchers interested in the applications of finite groups.

This third volume can be roughly divided into two parts. The first part is devoted to the investigation of various properties of projective characters. Special attention is drawn to spin representations and their character tables and to various correspondences for projective characters. Among other topics, projective Schur index and projective representations of abelian groups are covered. The last topic is investigated by introducing a symplectic geometry on finite abelian groups. The second part is devoted to Clifford theory for graded algebras and its application to the corresponding theory for group algebras. The volume ends with a detailed investigation of the Schur index for ordinary representations. A prominant role is played in the discussion by Brauer groups together with cyclotomic algebras and cyclic algebras.

This book is an outgrowth of a Research Symposium on the Modular Representation Theory of Finite Groups, held at the University of Virginia in May 1998. The main themes of this symposium were representations of groups of Lie type in nondefining (or cross) characteristic, and recent developments in block theory. Series of lectures were given by M. Geck, A. Kleshchev and R. Rouquier, and their brief was to present material at the leading edge of research but accessible to graduate students working in the field. The first three articles are substantial expansions of their lectures, and each provides a complete account of a significant area of the subject together with an extensive bibliography. The remaining articles are based on some of the other lectures given at the symposium; some again are full surveys of the topic covered while others are short, but complete, research articles. The opportunity has been taken to produce a book of enduring value so that this is not a conference proceedings in the conventional sense. Material has been updated so that this book, through its own content and in its extensive bibliographies, will serve as an invaluable resource for all those working in the area, whether established researchers or graduate students who wish to gain a general knowledge of the subject starting from a single source.

This book places character theory and its applications to finite groups within the reach of people with a comparatively modest mathematical background. The work concentrates mostly on applications of character theory to finite groups. The main themes are degrees and kernels of irreducible characters, the class number and the number of nonlinear irreducible characters, values of irreducible characters, characterizations and generalizations of Frobenius groups, and generalizations of monomial groups. The presentation is detailed, and many proofs of known results are new.

This book presents a systematic account of this topic, from the classical foundations established by Schur 80 years ago to current advances and developments in the field. This work focuses on general methods and builds theory solidly on the study of modules over twisted group algebras, and provides a wide range of skill-sharpening mathematical techniques applicable to this subject. Offers an understanding of projective representations of finite groups for algebraists, number theorists, mathematical researchers studying modern algebra, and theoretical physicists.

The present book, which is a revised edition of the author's book published in 1987 by Academic Press, is intended to give the reader an introduction to the theory of algebraic representations of reductive algebraic groups. To develop appropriate techniques, the first part of the book is an introduction to the general theory of representations of algebraic group schemes. Here the author describes, among others, such important basic notions as induction functor, cohomology, quotients, Frobenius kernels, and reduction mod p. The second part of the book is devoted to the representation theory of reductive algebraic groups. It includes such topics as the description of simple modules, vanishing theorems, the Borel-Bott-Weil theorem and Weyl's character formula, Schubert schemes and line bundles on them. For this revised edition the author added several chapters describing some later developments, among them Schur algebras, Lusztig's conjecture, and Kazhdan-Lusztig polynomials, tilting modules, and representations of quantum groups.
Character theory is a powerful tool for understanding finite groups. In particular, the theory has been a key ingredient in the classification of finite simple groups. Characters are also of interest in their own right, and their properties are closely related to properties of the structure of the underlying group. The book begins by developing the module theory of complex group algebras. After the module-theoretic foundations are laid in the first chapter, the focus is primarily on characters. This enhances the accessibility of the material for students, which was a major consideration in the writing. Also with students in mind, a large number of problems are included, many of them quite challenging. In addition to the development of the basic theory (using a cleaner notation than previously), a number of more specialized topics are covered with accessible presentations. These include projective representations, the basics of the Schur index, irreducible character degrees and group structure, complex linear groups, exceptional characters, and a fairly extensive introduction to blocks and Brauer characters. This is a corrected reprint of the original 1976 version, later reprinted by Dover. Since 1976 it has become the standard reference for character theory, appearing in the bibliography of almost every research paper in the subject. It is largely self-contained, requiring of the reader only the most basic facts of linear algebra, group theory, Galois theory and ring and module theory.
The purpose of this note is to investigate lifting problems for cocycle classes of projective representations of finite groups over a field k of characteristic 0 and to provide more detailed information in this respect if k is a number field. Some examples are discussed.

Proceedings of the Conference on Finite Groups provides information pertinent to the fundamental aspects of finite group theory. This book presents the problem of characterizing simple groups in terms of the local structure of a group. Organized into five parts encompassing 43 chapters, this book begins with an overview of the characterization of the Chevalley groups over fields of odd order and indicates the role of this characterization in the theory of component type groups. This text then examines the structure as well as the representations of specific simple groups. Other chapters consider the general theory of representations and characters of finite groups. This book discusses as well permutation groups and the connection between group theory and geometry. The final chapter deals with finite solvable groups as well as the theory of formations. This book is a valuable resource for mathematicians, graduate students, and research workers.

First published in 1962, this classic book remains a remarkably complete introduction to various aspects of the representation theory of finite groups. One of its main advantages is that the authors went far beyond the standard elementary representation theory, including a masterly treatment of topics such as general non-commutative algebras, Frobenius algebras, representations over non-algebraically closed fields and fields of non-zero characteristic, and integral representations. These and many other subjects are treated extremely thoroughly, starting with basic definitions and results and proceeding to many important and crucial developments. Numerous examples and exercises help the reader of this unsurpassed book to master this important area of mathematics.

The representation theory of finite groups has seen rapid growth in recent years with the development of efficient algorithms and computer algebra systems. This is the first book to provide an introduction to the ordinary and modular representation theory of finite groups with special emphasis on the computational aspects of the subject. Evolving from courses taught at Aachen University, this well-paced text is ideal for graduate-level study. The authors provide over 200 exercises, both theoretical and computational, and include worked examples using the computer algebra system GAP. These make the abstract theory tangible and engage students in real hands-on work. GAP is freely available from www.gap-system.org and readers can download source code and solutions to selected exercises from the book's web page.

This graduate textbook presents the basics of representation theory for finite groups from the point of view of semisimple algebras and modules over them. The presentation interweaves insights from specific examples with development of general and powerful tools based on the notion of semisimplicity. The elegant ideas of commutant duality are introduced, along with an introduction to representations of unitary groups. The text progresses systematically and the presentation is friendly and inviting. Central concepts are revisited and explored from multiple viewpoints. Exercises at the end of the chapter help reinforce the material. Representing Finite Groups: A Semisimple Introduction would serve as a textbook for graduate and some advanced undergraduate courses in mathematics. Prerequisites include acquaintance with elementary group theory and some familiarity with rings and modules. A final chapter presents a self-contained account of notions and results in algebra that are used. Researchers in mathematics and mathematical physics will also find this book useful. A separate solutions manual is available for instructors.

A comprehensive treatment of the representation theory of finite groups of Lie type over a field of the defining prime characteristic.

This graduate-level text provides a thorough grounding in the representation theory of finite groups over fields and rings. The book provides a balanced and comprehensive account of the subject, detailing the methods needed to analyze representations that arise in many areas of mathematics. Key topics include the construction and use of character tables, the role of induction and restriction, projective and simple modules for group algebras, indecomposable representations, Brauer characters, and block theory. This classroom-tested text provides motivation through a large number of worked examples, with exercises at the end of each chapter that test the reader's knowledge, provide further examples and practice, and include results not proven in the text. Prerequisites include a graduate course in abstract algebra, and familiarity with the properties of groups, rings, field extensions, and linear algebra.

Representation theory studies maps from groups into the general linear group of a finite-dimensional vector space. For finite groups the theory comes in two distinct flavours. In the 'semisimple case' (for example over the field of complex numbers) one can use character theory to completely understand the representations. This by far is not sufficient when the characteristic of the field divides the order of the group. Modular Representation Theory of finite Groups comprises this second situation. Many additional tools are needed for this case. To mention some, there is the systematic use of Grothendieck groups leading to the Cartan matrix and the decomposition matrix of the group as well as Green's direct analysis of indecomposable representations. There is also the strategy of writing the category of all representations as the direct product of certain subcategories, the so-called 'blocks' of the group. Brauer's work then establishes correspondences between the blocks of the original group and blocks of certain subgroups the philosophy being that one is thereby reduced to a simpler situation. In particular, one can measure how nonsemisimple a category a block is by the size and structure of its so-called 'defect group'. All these concepts are made explicit for the example of the special linear group of two-by-two matrices over a finite prime field. Although the presentation is strongly biased towards the module theoretic point of view an attempt is made to strike a certain balance by also showing the reader the group theoretic approach. In particular, in the case of defect groups a detailed proof of the equivalence of the two approaches is given. This book aims to familiarize students at the masters level with the basic results, tools, and techniques of a beautiful and important algebraic theory. Some basic algebra together with the semisimple case are assumed to be known, although all facts to be used are restated (without proofs) in the text. Otherwise the book is entirely self-contained.

This book consists of three parts, rather different in level and purpose. The first part was originally written for quantum chemists. It describes the correspondence, due to Frobenius, between linear representations and characters. The second part is a course given in 1966 to second-year students of l'Ecole Normale. It completes in a certain sense the first part. The third part is an introduction to Brauer Theory.

The study of the symmetric groups forms one of the basic building blocks of modern group theory. This book presents information currently known on the projective representations of the symmetric and alternating groups. Special emphasis is placed on the theory of Q--functions and skew Q-functions.