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This textbook provides an introduction to elementary category theory, with the aim of making what can be a confusing and sometimes overwhelming subject more accessible. In writing about this challenging subject, the author has brought to bear all of the experience he has gained in authoring over 30 books in university-level mathematics. The goal of this book is to present the five major ideas of category theory: categories, functors, natural transformations, universality, and adjoints in as friendly and relaxed a manner as possible while at the same time not sacrificing rigor. These topics are developed in a straightforward, step-by-step manner and are accompanied by numerous examples and exercises, most of which are drawn from abstract algebra. The first chapter of the book introduces the definitions of category and functor and discusses diagrams,duality, initial and terminal objects, special types of morphisms, and some special types of categories,particularly comma categories and hom-set categories. Chapter 2 is devoted to functors and naturaltransformations, concluding with Yoneda's lemma. Chapter 3 presents the concept of universality and Chapter 4 continues this discussion by exploring cones, limits, and the most common categorical constructions – products, equalizers, pullbacks and exponentials (along with their dual constructions). The chapter concludes with a theorem on the existence of limits. Finally, Chapter 5 covers adjoints and adjunctions. Graduate and advanced undergraduates students in mathematics, computer science, physics, or related fields who need to know or use category theory in their work will find An Introduction to Category Theory to be a concise and accessible resource. It will be particularly useful for those looking for a more elementary treatment of the topic before tackling more advanced texts. Category theory is a general mathematical theory of structures and of structures of structures. It occupied a central position in contemporary mathematics as well as computer science. This book describes the history of category theory whereby illuminating its symbiotic relationship to algebraic topology, homological algebra, algebraic geometry and mathematical logic and elaboratively develops the connections with the epistemological significance. Introduction to concepts of category theory — categories, functors, natural transformations, the Yoneda lemma, limits and colimits, adjunctions, monads — revisits a broad range of mathematical examples from the categorical perspective. 2016 edition. Basic Category Theory for Computer Scientists provides a straightforward presentation of the basic constructions and terminology of category theory, including limits, functors, natural transformations, adjoints, and cartesian closed categories. Category theory is a branch of pure mathematics that is becoming an increasingly important tool in theoretical computer science, especially in programming language semantics, domain theory, and concurrency, where it is already a standard language of discourse. Assuming a minimum of mathematical preparation, Basic Category Theory for Computer Scientists provides a straightforward presentation of the basic constructions and terminology of category theory, including limits, functors, natural transformations, adjoints, and cartesian closed categories. Four case studies illustrate applications of category theory to programming language design, semantics, and the solution of recursive domain equations. A brief literature survey offers suggestions for further study in more advanced texts. Contents Tutorial • Applications • Further Reading A short introduction ideal for students learning category theory for the first time. Category theory is a mathematical subject whose importance in several areas of computer science, most notably the semantics of programming languages and the design of programmes using abstract data types, is widely acknowledged. This book introduces category theory at a level appropriate for computer scientists and provides practical examples in the context of programming language design. Category Theory is one of the most abstract branches of mathematics. It is usually taught to graduate students after they have mastered several other branches of mathematics, like algebra, topology, and group theory. It might, therefore, come as a shock that the basic concepts of category theory can be explained in relatively simple terms to anybody with some experience in programming.That's because, just like programming, category theory is about structure. Mathematicians discover structure in mathematical theories, programmers discover structure in computer programs. Well-structured programs are easier to understand and maintain and are less likely to contain bugs. Category theory provides the language to talk about structure and learning it will make you a better programmer. Category theory has become increasingly important and popular in computer science, and many universities now have introductions to category theory as part of their courses for undergraduate computer scientists. The author is a respected category theorist and has based this textbook on a course given over the last few years at the University of Sydney. The theory is developed in a straightforward way, and is enriched with many examples from computer science. Thus this book meets the needs of undergradute computer scientists, and yet retains a level of mathematical correctness that will broaden its appeal to include students of mathematics new to category theory. The contributions gathered here demonstrate how categorical ontology can provide a basis for linking three important basic sciences: mathematics, physics, and philosophy. Category theory is a new formal ontology that shifts the main focus from objects to processes. The book approaches formal ontology in the original sense put forward by the philosopher Edmund Husserl, namely as a science that deals with entities that can be exemplified in all spheres and domains of reality. It is a dynamic, processual, and non-substantial ontology in which all entities can be treated as transformations, and in which objects are merely the sources and aims of these transformations. Thus, in a rather surprising way, when employed as a formal ontology, category theory can unite seemingly disparate disciplines in contemporary science and the humanities, such as physics, mathematics and philosophy, but also computer and complex systems science. Mathematician and popular science author Eugenia Cheng is on a mission to show you that mathematics can be flexible, creative, and visual. This joyful journey through the world of abstract mathematics into category theory will demystify mathematical thought processes and help you develop your own thinking, with no formal mathematical background needed. The book brings abstract mathematical ideas down to earth using examples of social justice, current events, and everyday life – from privilege to COVID-19 to driving routes. The journey begins with the ideas and workings of abstract mathematics, after which you will gently climb toward more technical material, learning everything needed to understand category theory, and then key concepts in category theory like natural transformations, duality, and even a glimpse of ongoing research in higher-dimensional category theory. For fans of How to Bake Pi, this will help you dig deeper into mathematical concepts and build your mathematical background. Category theory reveals commonalities between structures of all sorts. This book shows its potential in science, engineering, and beyond. A wide coverage of topics in category theory and computer science is developed in this text, including introductory treatments of cartesian closed categories, sketches and elementary categorical model theory, and triples.

Over 300 exercises are included. A comprehensive reference to category theory for students and researchers in mathematics, computer science, logic, cognitive science, linguistics, and philosophy. Useful for self-study and as a course text, the book includes all basic definitions and theorems (with full proofs), as well as numerous examples and exercises. The first of its kind, this book presents a widely accessible exposition of topos theory, aimed at the philosopher-logician as well as the mathematician. It is suitable for individual study or use in class at the graduate level (it includes 500 exercises). It begins with a fully motivated introduction to category theory itself, moving always from the particular example to the abstract concept. It then introduces the notion of elementary topos, with a wide range of examples and goes on to develop its theory in depth, and to elicit in detail its relationship to Kripke's intuitionistic semantics, models of classical set theory and the conceptual framework of sheaf theory (``localization'' of truth). Of particular interest is a Dedekind-cuts style construction of number systems in topoi, leading to a model of the intuitionistic continuum in which a ``Dedekind-real'' becomes represented as a ``continuously-variable classical real number''. The second edition contains a new chapter, entitled Logical Geometry, which introduces the reader to the theory of geometric morphisms of Grothendieck topoi, and its model-theoretic rendering by Makkai and Reyes. The aim of this chapter is to explain why Deligne's theorem about the existence of points of coherent topoi is equivalent to the classical Completeness theorem for ``geometric'' first-order formulae. ALLEN/GETTING THINGS DONE This truly elementary book on categories introduces retracts, graphs, and adjoints to students and scientists. This volume presents the proceedings of the workshop on higher category theory and mathematical physics held at Northwestern University. Exciting new developments were presented with the aim of making them better known outside the community of experts. In particular, presentations in the style, 'Higher Categories for the Working Mathematician', were encouraged. The volume is the first to bring together developments in higher category theory with applications. This collection is a valuable introduction to this topic - one that holds great promise for future developments in mathematics. Algebra, Topology, and Category Theory: A Collection of Papers in Honor of Samuel Eilenberg is a collection of papers dealing with algebra, topology, and category theory in honor of Samuel Eilenberg. Topics covered range from large modules over artin algebras to two-dimensional Poincaré duality groups, along with the homology of certain H-spaces as group ring objects. Variable quantities and variable structures in topoi are also discussed. Comprised of 16 chapters, this book begins by looking at the relationship between the representation theories of finitely generated and large (not finitely generated) modules over an artin algebra. The reader is then introduced to reduced bar constructions on deRham complexes; some properties of two-dimensional Poincaré duality groups; and properties invariant within equivalence types of categories. Subsequent chapters explore the work of Samuel Eilenberg in topology; local complexity of finite semigroups; global dimension of ore extensions; and the spectrum of a ringed topos. This monograph will be a useful resource for students and practitioners of algebra and mathematics. Using basic category theory, this Element describes all the central concepts and proves the main theorems of theoretical computer science. Category theory, which works with functions, processes, and structures, is uniquely qualified to present the fundamental results of theoretical computer science. In this Element, readers will meet some of the deepest ideas and theorems of modern computers and mathematics, such as Turing machines, unsolvable problems, the P=NP question, Kurt Gödel's incompleteness theorem, intractable problems, cryptographic protocols, Alan Turing's Halting problem, and much more. The concepts come alive with many examples and exercises. Category Theory has developed rapidly. This book aims to present those ideas and methods which can now be effectively used by Mathe maticians working in a variety of other fields of Mathematical research. This occurs at several levels. On the first level, categories provide a convenient conceptual language, based on the notions of category, functor, natural

transformation, contravariance, and functor category. These notions are presented, with appropriate examples, in Chapters I and II. Next comes the fundamental idea of an adjoint pair of functors. This appears in many substantially equivalent forms: That of universal construction, that of direct and inverse limit, and that of pairs offunctors with a natural isomorphism between corresponding sets of arrows. All these forms, with their interrelations, are examined in Chapters III to V. The slogan is "Adjoint functors arise everywhere". Alternatively, the fundamental notion of category theory is that of a monoid -a set with a binary operation of multiplication which is associative and which has a unit; a category itself can be regarded as a sort of general ized monoid. Chapters VI and VII explore this notion and its generaliza tions. Its close connection to pairs of adjoint functors illuminates the ideas of universal algebra and culminates in Beck's theorem characterizing categories of algebras; on the other hand, categories with a monoidal structure (given by a tensor product) lead inter alia to the study of more convenient categories of topological spaces. Category theory provides structure for the mathematical world and is seen everywhere in modern mathematics. With this book, the author bridges the gap between pure category theory and its numerous applications in homotopy theory, providing the necessary background information to make the subject accessible to graduate students or researchers with a background in algebraic topology and algebra. The reader is first introduced to category theory, starting with basic definitions and concepts before progressing to more advanced themes. Concrete examples and exercises illustrate the topics, ranging from colimits to constructions such as the Day convolution product. Part II covers important applications of category theory, giving a thorough introduction to simplicial objects including an account of quasi-categories and Segal sets. Diagram categories play a central role throughout the book, giving rise to models of iterated loop spaces, and feature prominently in functor homology and homology of small categories. This textbook explains the basic principles of categorical type theory and the techniques used to derive categorical semantics for specific type theories. It introduces the reader to ordered set theory, lattices and domains, and this material provides plenty of examples for an introduction to category theory, which covers categories, functors, natural transformations, the Yoneda lemma, cartesian closed categories, limits, adjunctions and indexed categories. Four kinds of formal system are considered in detail, namely algebraic, functional, polymorphic functional, and higher order polymorphic functional type theory. For each of these the categorical semantics are derived and results about the type systems are proved categorically. Issues of soundness and completeness are also considered. Aimed at advanced undergraduates and beginning graduates, this book will be of interest to theoretical computer scientists, logicians and mathematicians specializing in category theory. Category Theory now permeates most of Mathematics, large parts of theoretical Computer Science and parts of theoretical Physics. Its unifying power brings together different branches, and leads to a better understanding of their roots.This book is addressed to students and researchers of these fields and can be used as a text for a first course in Category Theory. It covers the basic tools, like universal properties, limits, adjoint functors and monads. These are presented in a concrete way, starting from examples and exercises taken from elementary Algebra, Lattice Theory and Topology, then developing the theory together with new exercises and applications.A reader should have some elementary knowledge of these three subjects, or at least two of them, in order to be able to follow the main examples, appreciate the unifying power of the categorical approach, and discover the subterranean links brought to light and formalised by this perspective.Applications of Category Theory form a vast and differentiated domain. This book wants to present the basic applications in Algebra and Topology, with a choice of more advanced ones, based on the interests of the author. References are given for applications in many other fields.In this second edition, the book has been entirely reviewed, adding many applications and exercises. All non-obvious exercises have now a solution (or a reference, in the case of an advanced topic);

solutions are now collected in the last chapter. This book develops the theory of infinite-dimensional categories by studying the universe, or ?-cosmos, in which they live. This book outlines a vast array of techniques and methods regarding model categories, without focussing on the intricacies of the proofs. Quillen model categories are a fundamental tool for the understanding of homotopy theory. While many introductions to model categories fall back on the same handful of canonical examples, the present book highlights a large, self-contained collection of other examples which appear throughout the literature. In particular, it collects a highly scattered literature into a single volume. The book is aimed at anyone who uses, or is interested in using, model categories to study homotopy theory. It is written in such a way that it can be used as a reference guide for those who are already experts in the field. However, it can also be used as an introduction to the theory for novices. Algebra: Chapter 0 is a self-contained introduction to the main topics of algebra, suitable for a first sequence on the subject at the beginning graduate or upper undergraduate level. The primary distinguishing feature of the book, compared to standard textbooks in algebra, is the early introduction of categories, used as a unifying theme in the presentation of the main topics. A second feature consists of an emphasis on homological algebra: basic notions on complexes are presented as soon as modules have been introduced, and an extensive last chapter on homological algebra can form the basis for a follow-up introductory course on the subject. Approximately 1,000 exercises both provide adequate practice to consolidate the understanding of the main body of the text and offer the opportunity to explore many other topics, including applications to number theory and algebraic geometry. This will allow instructors to adapt the textbook to their specific choice of topics and provide the independent reader with a richer exposure to algebra. Many exercises include substantial hints, and navigation of the topics is facilitated by an extensive index and by hundreds of cross-references. Category theory emerged in the 1940s in the work of Samuel Eilenberg and Saunders Mac Lane. It describes relationships between mathematical structures. Outside of pure mathematics, category theory is an important tool in physics, computer science, linguistics, and a quickly-growing list of other sciences. This book is about 2-dimensional categories, which add an extra dimension of richness and complexity to category theory. 2-Dimensional Categories is an introduction to 2-categories and bicategories, assuming only the most elementary aspects of category theory. A review of basic category theory is followed by a systematic discussion of 2-/bicategories, pasting diagrams, lax functors, 2-/bilimits, the Duskin nerve, 2-nerve, internal adjunctions, monads in bicategories, 2-monads, biequivalences, the Bicategorical Yoneda Lemma, and the Coherence Theorem for bicategories. Grothendieck fibrations and the Grothendieck construction are discussed next, followed by tricategories, monoidal bicategories, the Gray tensor product, and double categories. Completely detailed proofs of several fundamental but hard-to-find results are presented for the first time. With exercises and plenty of motivation and explanation, this book is useful for both beginners and experts. This is the Scala edition of Category Theory for Programmers by Bartosz Milewski. This book contains code snippets in both Haskell and Scala. Containing example exercises, this reference to category theory is suitable for researchers and graduates in philosophy, mathematics, and computer science. With definitions of concepts, and proofs of propositions and theorems, the text makes the ideas of this topic understandable to the broad readership. Categories and sheaves appear almost frequently in contemporary advanced mathematics. This book covers categories, homological algebra and sheaves in a systematic manner starting from scratch and continuing with full proofs to the most recent results in the literature, and sometimes beyond. The authors present the general theory of categories and functors, emphasizing inductive and projective limits, tensor categories, representable functors, ind-objects and localization. In this book, first published in 2003, categorical algebra is used to build a foundation for the study of geometry, analysis, and algebra. Category theory provides a general conceptual framework that has proved fruitful in subjects as diverse as geometry,

topology, theoretical computer science and foundational mathematics. Here is a friendly, easy-to-read textbook that explains the fundamentals at a level suitable for newcomers to the subject. Beginning postgraduate mathematicians will find this book an excellent introduction to all of the basics of category theory. It gives the basic definitions; goes through the various associated gadgetry, such as functors, natural transformations, limits and colimits; and then explains adjunctions. The material is slowly developed using many examples and illustrations to illuminate the concepts explained. Over 200 exercises, with solutions available online, help the reader to access the subject and make the book ideal for self-study. It can also be used as a recommended text for a taught introductory course. This is the first book on category theory for a broad philosophical readership. There is no other discussion of category theory comparable in its scope. It is designed to show the interest and significant of category theory for philosophers working in a range of areas, including mathematics, proof theory, computer science, ontology, physics, biology, cognition, mathematical modelling, the structure of scientific theories, and the structure of the world. Moreover, it does this in a way that is accessible to non specialists. Each chapter is written by either a category-theorist or a philosopher working in one of the represented fields, in a way that builds on the concepts already familiar to philosophers working in these areas. The book is split into two halves. The 'pure' chapters focus on the use of category theory for mathematical, foundational, and logical purposes, while the 'applied' chapters consider the use of category theory for representational purposes, investigating category theory as a framework for theories of physics and biology, for mathematical modelling more generally, and for the structure of scientific theories. Book jacket. A graduate-level textbook that presents basic topology from the perspective of category theory. This graduate-level textbook on topology takes a unique approach: it reintroduces basic, point-set topology from a more modern, categorical perspective. Many graduate students are familiar with the ideas of point-set topology and they are ready to learn something new about them. Teaching the subject using category theory--a contemporary branch of mathematics that provides a way to represent abstract concepts--both deepens students' understanding of elementary topology and lays a solid foundation for future work in advanced topics. An introduction to category theory as a rigorous, flexible, and coherent modeling language that can be used across the sciences. Category theory was invented in the 1940s to unify and synthesize different areas in mathematics, and it has proven remarkably successful in enabling powerful communication between disparate fields and subfields within mathematics. This book shows that category theory can be useful outside of mathematics as a rigorous, flexible, and coherent modeling language throughout the sciences. Information is inherently dynamic; the same ideas can be organized and reorganized in countless ways, and the ability to translate between such organizational structures is becoming increasingly important in the sciences. Category theory offers a unifying framework for information modeling that can facilitate the translation of knowledge between disciplines. Written in an engaging and straightforward style, and assuming little background in mathematics, the book is rigorous but accessible to non-mathematicians. Using databases as an entry to category theory, it begins with sets and functions, then introduces the reader to notions that are fundamental in mathematics: monoids, groups, orders, and graphs—categories in disguise. After explaining the “big three” concepts of category theory—categories, functors, and natural transformations—the book covers other topics, including limits, colimits, functor categories, sheaves, monads, and operads. The book explains category theory by examples and exercises rather than focusing on theorems and proofs. It includes more than 300 exercises, with solutions. Category Theory for the Sciences is intended to create a bridge between the vast array of mathematical concepts used by mathematicians and the models and frameworks of such scientific disciplines as computation, neuroscience, and physics.

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