

# MSC2020-Mathematical Sciences Classification System

## Editors of Mathematical Reviews and zbMATH

- 00 General and overarching topics; collections
- 01 History and biography
- 03 Mathematical logic and foundations
- 05 Combinatorics
- 06 Order, lattices, ordered algebraic structures
- 08 General algebraic systems
- 11 Number theory
- 12 Field theory and polynomials
- 13 Commutative algebra
- 14 Algebraic geometry
- 15 Linear and multilinear algebra; matrix theory
- 16 Associative rings and algebras
- 17 Nonassociative rings and algebras
- 18 Category theory; homological algebra
- 19  $K$ -theory
- 20 Group theory and generalizations
- 22 Topological groups, Lie groups
- 26 Real functions
- 28 Measure and integration
- 30 Functions of a complex variable
- 31 Potential theory
- 32 Several complex variables and analytic spaces
- 33 Special functions
- 34 Ordinary differential equations
- 35 Partial differential equations
- 37 Dynamical systems and ergodic theory
- 39 Difference and functional equations
- 40 Sequences, series, summability
- 41 Approximations and expansions
- 42 Harmonic analysis on Euclidean spaces
- 43 Abstract harmonic analysis
- 44 Integral transforms, operational calculus
- 45 Integral equations
- 46 Functional analysis
- 47 Operator theory
- 49 Calculus of variations and optimal control; optimization
- 51 Geometry
- 52 Convex and discrete geometry
- 53 Differential geometry
- 54 General topology
- 55 Algebraic topology
- 57 Manifolds and cell complexes
- 58 Global analysis, analysis on manifolds
- 60 Probability theory and stochastic processes
- 62 Statistics
- 65 Numerical analysis
- 68 Computer science
- 70 Mechanics of particles and systems
- 74 Mechanics of deformable solids
- 76 Fluid mechanics
- 78 Optics, electromagnetic theory
- 80 Classical thermodynamics, heat transfer
- 81 Quantum theory
- 82 Statistical mechanics, structure of matter
- 83 Relativity and gravitational theory
- 85 Astronomy and astrophysics
- 86 Geophysics
- 90 Operations research, mathematical programming
- 91 Game theory, economics, social and behavioral sciences
- 92 Biology and other natural sciences
- 93 Systems theory; control
- 94 Information and communication, circuits
- 97 Mathematics education

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This document is a printed form of MSC2020, an MSC revision produced jointly by the editorial staffs of Mathematical Reviews (MR) and zbMATH in consultation with the mathematical community. The goals of this revision of the Mathematics Subject Classification (MSC) were set out in the announcement of it and call for comments by the Executive Editor of MR and the Editor-in-Chief of zbMATH in July 2016.

## How to use the Mathematics Subject Classification [MSC]

The main purpose of the classification of items in the mathematical literature using the Mathematics Subject Classification scheme is to help users find the items of present or potential interest to them as readily as possible—in products derived from the Mathematical Reviews Database (MRDB) such as MathSciNet, in Zentralblatt MATH (zbMATH), or anywhere else where this classification scheme is used. An item in the mathematical literature should be classified so as to attract the attention of all those possibly interested in it. The item may be something that falls squarely within one clear area of the MSC, or it may involve several areas. Ideally, the MSC codes attached to an item should represent the subjects to which the item contains a contribution. The classification should serve both those closely concerned with specific subject areas, and those familiar enough with subjects to apply their results and methods elsewhere, inside or outside of mathematics. It will be extremely useful for both users and classifiers to familiarize themselves with the entire classification system and thus to become aware of all the classifications of possible interest to them. Every item in the MRDB or zbMATH receives precisely one primary classification, which is simply the MSC code that describes its principal contribution. When an item contains several principal contributions to different areas, the primary classification should cover the most important among them. A paper or book may be assigned one or several secondary classification numbers to cover any remaining principal contributions, ancillary results, motivation or origin of the matters discussed, intended or potential field of application, or other significant aspects worthy of notice. The principal contribution is meant to be the one including the most important part of the work actually done in the item. For example, a paper whose main overall content is the solution of a problem in graph theory, which arose in computer science and whose solution is (perhaps) at present only of interest to computer scientists, would have a primary classification in 05C (Graph Theory) with one or more secondary classifications in 68 (Computer Science); conversely, a paper whose overall content lies mainly in computer science should receive a primary classification in 68, even if it makes heavy use of graph theory and proves several new graph-theoretic results along the way. There are two types of cross-references given at the end of many of the MSC2020 entries in the MSC. The first type is in braces: “{For A, see X}”; if this appears in section Y, it means that contributions described by A should usually be assigned the classification code X, not Y. The other type of cross-reference merely points out related classifications; it is in brackets: “[See also ...]”, “[See mainly ...]”, etc., and the classification codes listed in the brackets may, but need not, be included in the classification codes of a paper, or they may be used in place of the classification where the cross-reference is given. The classifier must judge which classification is the most appropriate for the paper at hand.

## 00-XX General and overarching topics; collections

- 00-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to mathematics in general
- 00-02 Research exposition (monographs, survey articles) pertaining to mathematics in general

## 00Axx General and miscellaneous specific topics

- 00A05 Mathematics in general
- 00A06 Mathematics for nonmathematicians (engineering, social sciences, etc.)
- 00A07 Problem books {For open problems, see 00A27}
- 00A08 Recreational mathematics
- 00A09 Popularization of mathematics
- 00A15 Bibliographies for mathematics in general [See also 01A70 and the classification number -00 in the other sections]
- 00A17 External book reviews
- 00A20 Dictionaries and other general reference works [See also the classification number -00 in the other sections]
- 00A22 Formularies
- 00A27 Lists of open problems
- 00A30 Philosophy of mathematics [See also 03A05]
- 00A35 Methodology of mathematics {For mathematics education, see 97-XX}
- 00A64 Mathematics and literature
- 00A65 Mathematics and music
- 00A66 Mathematics and visual arts
- 00A67 Mathematics and architecture
- 00A69 General applied mathematics {For physics, see 00A79 and Sections 70 through 86}
- 00A71 General theory of mathematical modeling
- 00A72 General theory of simulation
- 00A79 Physics (Use more specific entries from Sections 70 through 86 when possible)
- 00A99 None of the above, but in this section

## 00Bxx Conference proceedings and collections of articles

- 00B05 Collections of abstracts of lectures
- 00B10 Collections of articles of general interest
- 00B15 Collections of articles of miscellaneous specific interest
- 00B20 Proceedings of conferences of general interest
- 00B25 Proceedings of conferences of miscellaneous specific interest

00B30 Festschriften

00B50 Collections of translated articles of general interest

00B55 Collections of translated articles of miscellaneous specific interest

00B60 Collections of reprinted articles [See also 01A75]

00B99 None of the above, but in this section

## 01-XX History and biography [See also the classification number -03 in the other sections]

01-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to history and biography

01-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to history and biography

01-02 Research exposition (monographs, survey articles) pertaining to history and biography

01-06 Proceedings, conferences, collections, etc. pertaining to history and biography

01-11 Research data for problems pertaining to history and biography

## 01Axx History of mathematics and mathematicians

01A05 General histories, source books

01A07 Ethnomathematics, general

01A10 History of mathematics in Paleolithic and Neolithic times

01A11 History of mathematics of the indigenous cultures of Africa, Asia, and Oceania

01A12 History of mathematics of the indigenous cultures of the Americas

01A15 History of mathematics of the indigenous cultures of Europe (pre-Greek, etc.)

01A16 History of mathematics in Ancient Egypt

01A17 History of mathematics in Ancient Babylon

01A20 History of mathematics in Ancient Greece and Rome

01A25 History of mathematics in China

01A27 History of mathematics in Japan

01A29 History of mathematics in Southeast Asia

01A30 History of mathematics in the Golden Age of Islam

01A32 History of mathematics in India

01A35 History of mathematics in late antiquity and medieval Europe

01A40 History of mathematics in the 15th and 16th centuries, Renaissance

01A45 History of mathematics in the 17th century

01A50 History of mathematics in the 18th century

01A55 History of mathematics in the 19th century

- 01A60** History of mathematics in the 20th century
- 01A61** History of mathematics in the 21st century
- 01A65** Development of contemporary mathematics
- 01A67** Future perspectives in mathematics
- 01A70** Biographies, obituaries, personalia, bibliographies
- 01A72** Schools of mathematics
- 01A73** History of mathematics at specific universities
- 01A74** History of mathematics at institutions and academies (non-university)
- 01A75** Collected or selected works; reprintings or translations of classics [See also [00B60](#)]
- 01A80** Sociology (and profession) of mathematics
- 01A85** Historiography
- 01A90** Bibliographic studies
- 01A99** None of the above, but in this section

## 03-XX Mathematical logic and foundations

- 03-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to mathematical logic and foundations
- 03-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to mathematical logic and foundations
- 03-02** Research exposition (monographs, survey articles) pertaining to mathematical logic and foundations
- 03-03** History of mathematical logic and foundations [Consider also classification numbers pertaining to [Section 01](#)]
- 03-04** Software, source code, etc. for problems pertaining to mathematical logic and foundations
- 03-06** Proceedings, conferences, collections, etc. pertaining to mathematical logic and foundations
- 03-08** Computational methods for problems pertaining to mathematical logic and foundations
- 03-11** Research data for problems pertaining to mathematical logic and foundations

## 03Axx Philosophical aspects of logic and foundations

- 03A05** Philosophical and critical aspects of logic and foundations {For philosophy of mathematics, see also [00A30](#)}
- 03A10** Logic in the philosophy of science
- 03A99** None of the above, but in this section

## 03Bxx General logic

- 03B05** Classical propositional logic
- 03B10** Classical first-order logic
- 03B16** Higher-order logic
- 03B20** Subsystems of classical logic (including intuitionistic logic)
- 03B22** Abstract deductive systems
- 03B25** Decidability of theories and sets of sentences [See also [11U05](#), [12L05](#), [20F10](#)]
- 03B30** Foundations of classical theories (including reverse mathematics) [See also [03F35](#)]
- 03B35** Mechanization of proofs and logical operations [See also [68V15](#)]
- 03B38** Type theory
- 03B40** Combinatory logic and lambda calculus [See also [68N18](#)]
- 03B42** Logics of knowledge and belief (including belief change)
- 03B44** Temporal logic
- 03B45** Modal logic (including the logic of norms) {For knowledge and belief, see [03B42](#); for temporal logic, see [03B44](#); for provability logic, see also [03F45](#)}
- 03B47** Substructural logics (including relevance, entailment, linear logic, Lambek calculus, BCK and BCI logics) {For proof-theoretic aspects see [03F52](#)}
- 03B48** Probability and inductive logic [See also [60A05](#)]
- 03B50** Many-valued logic
- 03B52** Fuzzy logic; logic of vagueness [See also [68T27](#), [68T37](#), [94D05](#)]
- 03B53** Paraconsistent logics
- 03B55** Intermediate logics
- 03B60** Other nonclassical logic
- 03B62** Combined logics
- 03B65** Logic of natural languages [See also [68T50](#), [91F20](#)]
- 03B70** Logic in computer science [See also [68-XX](#)]
- 03B80** Other applications of logic
- 03B99** None of the above, but in this section

## 03Cxx Model theory

- 03C05** Equational classes, universal algebra in model theory [See also [08Axx](#), [08Bxx](#), [18C05](#)]
- 03C07** Basic properties of first-order languages and structures
- 03C10** Quantifier elimination, model completeness and related topics
- 03C13** Model theory of finite structures [See also [68Q15](#), [68Q19](#)]

- 03C15** Model theory of denumerable and separable structures
  - 03C20** Ultraproducts and related constructions
  - 03C25** Model-theoretic forcing
  - 03C30** Other model constructions
  - 03C35** Categoricity and completeness of theories
  - 03C40** Interpolation, preservation, definability
  - 03C45** Classification theory, stability and related concepts in model theory [See also [03C48](#)]
  - 03C48** Abstract elementary classes and related topics [See also [03C45](#)]
  - 03C50** Models with special properties (saturated, rigid, etc.)
  - 03C52** Properties of classes of models
  - 03C55** Set-theoretic model theory
  - 03C57** Computable structure theory, computable model theory [See also [03D45](#)]
  - 03C60** Model-theoretic algebra [See also [08C10](#), [12Lxx](#), [13L05](#)]
  - 03C62** Models of arithmetic and set theory [See also [03Hxx](#)]
  - 03C64** Model theory of ordered structures; o-minimality
  - 03C65** Models of other mathematical theories
  - 03C66** Continuous model theory, model theory of metric structures
  - 03C68** Other classical first-order model theory
  - 03C70** Logic on admissible sets
  - 03C75** Other infinitary logic
  - 03C80** Logic with extra quantifiers and operators [See also [03B42](#), [03B44](#), [03B45](#), [03B48](#)]
  - 03C85** Second- and higher-order model theory
  - 03C90** Nonclassical models (Boolean-valued, sheaf, etc.)
  - 03C95** Abstract model theory
  - 03C98** Applications of model theory [See also [03C60](#)]
  - 03C99** None of the above, but in this section
- 03Dxx Computability and recursion theory**
- 03D03** Thue and Post systems, etc.
  - 03D05** Automata and formal grammars in connection with logical questions [See also [68Q45](#), [68Q70](#), [68R15](#)]
  - 03D10** Turing machines and related notions [See also [68Q04](#)]
  - 03D15** Complexity of computation (including implicit computational complexity) [See also [68Q15](#), [68Q17](#)]
  - 03D20** Recursive functions and relations, subrecursive hierarchies
  - 03D25** Recursively (computably) enumerable sets and degrees
  - 03D28** Other Turing degree structures
  - 03D30** Other degrees and reducibilities in computability and recursion theory
  - 03D32** Algorithmic randomness and dimension [See also [68Q30](#)]
  - 03D35** Undecidability and degrees of sets of sentences
  - 03D40** Word problems, etc. in computability and recursion theory [See also [06B25](#), [08A50](#), [20F10](#), [68R15](#)]
  - 03D45** Theory of numerations, effectively presented structures [See also [03C57](#)] {For intuitionistic and similar approaches, see [03F55](#)}
  - 03D50** Recursive equivalence types of sets and structures, isols
  - 03D55** Hierarchies of computability and definability
  - 03D60** Computability and recursion theory on ordinals, admissible sets, etc.
  - 03D65** Higher-type and set recursion theory
  - 03D70** Inductive definability
  - 03D75** Abstract and axiomatic computability and recursion theory
  - 03D78** Computation over the reals, computable analysis {For constructive aspects, see [03F60](#)}
  - 03D80** Applications of computability and recursion theory
  - 03D99** None of the above, but in this section
- 03Exx Set theory**
- 03E02** Partition relations
  - 03E04** Ordered sets and their cofinalities; pcf theory
  - 03E05** Other combinatorial set theory
  - 03E10** Ordinal and cardinal numbers
  - 03E15** Descriptive set theory [See also [28A05](#), [54H05](#)]
  - 03E17** Cardinal characteristics of the continuum
  - 03E20** Other classical set theory (including functions, relations, and set algebra)
  - 03E25** Axiom of choice and related propositions
  - 03E30** Axiomatics of classical set theory and its fragments
  - 03E35** Consistency and independence results
  - 03E40** Other aspects of forcing and Boolean-valued models
  - 03E45** Inner models, including constructibility, ordinal definability, and core models
  - 03E47** Other notions of set-theoretic definability
  - 03E50** Continuum hypothesis and Martin's axiom [See also [03E57](#)]
  - 03E55** Large cardinals
  - 03E57** Generic absoluteness and forcing axioms [See also [03E50](#)]
  - 03E60** Determinacy principles
  - 03E65** Other set-theoretic hypotheses and axioms
  - 03E70** Nonclassical and second-order set theories
  - 03E72** Theory of fuzzy sets, etc.
  - 03E75** Applications of set theory
  - 03E99** None of the above, but in this section

## 03Fxx Proof theory and constructive mathematics

- 03F03 Proof theory, general (including proof-theoretic semantics)
- 03F05 Cut-elimination and normal-form theorems
- 03F07 Structure of proofs
- 03F10 Functionals in proof theory
- 03F15 Recursive ordinals and ordinal notations
- 03F20 Complexity of proofs
- 03F25 Relative consistency and interpretations
- 03F30 First-order arithmetic and fragments
- 03F35 Second- and higher-order arithmetic and fragments [See also 03B30]
- 03F40 Gödel numberings and issues of incompleteness
- 03F45 Provability logics and related algebras (e.g., diagonalizable algebras) [See also 03B45, 03G25, 06E25]
- 03F50 Metamathematics of constructive systems
- 03F52 Proof-theoretic aspects of linear logic and other substructural logics [See also 03B47]
- 03F55 Intuitionistic mathematics
- 03F60 Constructive and recursive analysis [See also 03B30, 03D45, 03D78, 26E40, 46S30, 47S30]
- 03F65 Other constructive mathematics [See also 03D45]
- 03F99 None of the above, but in this section

## 03Gxx Algebraic logic

- 03G05 Logical aspects of Boolean algebras [See also 06Exx]
- 03G10 Logical aspects of lattices and related structures [See also 06Bxx]
- 03G12 Quantum logic [See also 06C15, 81P10]
- 03G15 Cylindric and polyadic algebras; relation algebras
- 03G20 Logical aspects of Łukasiewicz and Post algebras [See also 06D25, 06D30]
- 03G25 Other algebras related to logic [See also 03F45, 06D20, 06E25, 06F35]
- 03G27 Abstract algebraic logic
- 03G30 Categorical logic, topoi [See also 18B25, 18C05, 18C10]
- 03G99 None of the above, but in this section

## 03Hxx Nonstandard models [See also 03C62]

- 03H05 Nonstandard models in mathematics [See also 26E35, 28E05, 30G06, 46S20, 47S20, 54J05]
- 03H10 Other applications of nonstandard models (economics, physics, etc.)
- 03H15 Nonstandard models of arithmetic [See also 11U10, 12L15, 13L05]
- 03H99 None of the above, but in this section

## 05-XX Combinatorics {For finite fields, see 11Txx}

- 05-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to combinatorics
- 05-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to combinatorics
- 05-02 Research exposition (monographs, survey articles) pertaining to combinatorics
- 05-03 History of combinatorics [Consider also classification numbers pertaining to Section 01]
- 05-04 Software, source code, etc. for problems pertaining to combinatorics
- 05-06 Proceedings, conferences, collections, etc. pertaining to combinatorics
- 05-08 Computational methods for problems pertaining to combinatorics
- 05-11 Research data for problems pertaining to combinatorics

## 05Axx Enumerative combinatorics {For enumeration in graph theory, see 05C30}

- 05A05 Permutations, words, matrices
- 05A10 Factorials, binomial coefficients, combinatorial functions [See also 11B65, 33Cxx]
- 05A15 Exact enumeration problems, generating functions [See also 33Cxx, 33Dxx]
- 05A16 Asymptotic enumeration
- 05A17 Combinatorial aspects of partitions of integers [See also 11P81, 11P82, 11P83]
- 05A18 Partitions of sets
- 05A19 Combinatorial identities, bijective combinatorics
- 05A20 Combinatorial inequalities
- 05A30  $q$ -calculus and related topics [See also 33Dxx]
- 05A40 Umbral calculus
- 05A99 None of the above, but in this section



## **05Bxx Designs and configurations {For applications of design theory, see 94C30}**

- 05B05** Combinatorial aspects of block designs [See also [51E05](#), [62K10](#)]
- 05B07** Triple systems
- 05B10** Combinatorial aspects of difference sets (number-theoretic, group-theoretic, etc.) [See also [11B13](#)]
- 05B15** Orthogonal arrays, Latin squares, Room squares
- 05B20** Combinatorial aspects of matrices (incidence, Hadamard, etc.)
- 05B25** Combinatorial aspects of finite geometries [See also [51D20](#), [51Exx](#)]
- 05B30** Other designs, configurations [See also [51E30](#)]
- 05B35** Combinatorial aspects of matroids and geometric lattices [See also [52B40](#), [90C27](#)]
- 05B40** Combinatorial aspects of packing and covering [See also [11H31](#), [52C15](#), [52C17](#)]
- 05B45** Combinatorial aspects of tessellation and tiling problems [See also [52C20](#), [52C22](#)]
- 05B50** Polyominoes
- 05B99** None of the above, but in this section

## **05Cxx Graph theory {For applications of graphs, see 68R10, 81Q30, 81T15, 82B20, 82C20, 90C35, 92E10, 94C15}**

- 05C05** Trees
- 05C07** Vertex degrees [See also [05E30](#)]
- 05C09** Graphical indices (Wiener index, Zagreb index, Randić index, etc.)
- 05C10** Planar graphs; geometric and topological aspects of graph theory [See also [57K10](#), [57M15](#)]
- 05C12** Distance in graphs
- 05C15** Coloring of graphs and hypergraphs
- 05C17** Perfect graphs
- 05C20** Directed graphs (digraphs), tournaments
- 05C21** Flows in graphs
- 05C22** Signed and weighted graphs
- 05C25** Graphs and abstract algebra (groups, rings, fields, etc.) [See also [20F65](#)]
- 05C30** Enumeration in graph theory
- 05C31** Graph polynomials
- 05C35** Extremal problems in graph theory [See also [90C35](#)]
- 05C38** Paths and cycles [See also [90B10](#)]
- 05C40** Connectivity
- 05C42** Density (toughness, etc.)
- 05C45** Eulerian and Hamiltonian graphs
- 05C48** Expander graphs

- 05C50** Graphs and linear algebra (matrices, eigenvalues, etc.)
- 05C51** Graph designs and isomorphic decomposition [See also [05B30](#)]
- 05C55** Generalized Ramsey theory [See also [05D10](#)]
- 05C57** Games on graphs (graph-theoretic aspects) [See also [91A43](#), [91A46](#)]
- 05C60** Isomorphism problems in graph theory (reconstruction conjecture, etc.) and homomorphisms (subgraph embedding, etc.)
- 05C62** Graph representations (geometric and intersection representations, etc.) {For graph drawing, see also [68R10](#)}
- 05C63** Infinite graphs
- 05C65** Hypergraphs
- 05C69** Vertex subsets with special properties (dominating sets, independent sets, cliques, etc.)
- 05C70** Edge subsets with special properties (factorization, matching, partitioning, covering and packing, etc.)
- 05C72** Fractional graph theory, fuzzy graph theory
- 05C75** Structural characterization of families of graphs
- 05C76** Graph operations (line graphs, products, etc.)
- 05C78** Graph labelling (graceful graphs, bandwidth, etc.)
- 05C80** Random graphs (graph-theoretic aspects) [See also [60B20](#)]
- 05C81** Random walks on graphs
- 05C82** Small world graphs, complex networks (graph-theoretic aspects) [See also [90Bxx](#), [91D30](#)]
- 05C83** Graph minors
- 05C85** Graph algorithms (graph-theoretic aspects) [See also [68R10](#), [68W05](#)]
- 05C90** Applications of graph theory [See also [68R10](#), [81Q30](#), [81T15](#), [82B20](#), [82C20](#), [90C35](#), [92E10](#), [94C15](#)]
- 05C92** Chemical graph theory [See also [92E10](#)]
- 05C99** None of the above, but in this section

## **05Dxx Extremal combinatorics**

- 05D05** Extremal set theory
- 05D10** Ramsey theory [See also [05C55](#)]
- 05D15** Transversal (matching) theory
- 05D40** Probabilistic methods in extremal combinatorics, including polynomial methods (combinatorial Nullstellensatz, etc.)
- 05D99** None of the above, but in this section



## 05Exx Algebraic combinatorics

- 05E05 Symmetric functions and generalizations
- 05E10 Combinatorial aspects of representation theory [See also 20C30]
- 05E14 Combinatorial aspects of algebraic geometry [See also 14Nxx]
- 05E16 Combinatorial aspects of groups and algebras [See also 22E45, 33C80]
- 05E18 Group actions on combinatorial structures
- 05E30 Association schemes, strongly regular graphs
- 05E40 Combinatorial aspects of commutative algebra
- 05E45 Combinatorial aspects of simplicial complexes
- 05E99 None of the above, but in this section

## 06-XX Order, lattices, ordered algebraic structures [See also 18B35]

- 06-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to ordered structures
- 06-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to ordered structures
- 06-02 Research exposition (monographs, survey articles) pertaining to ordered structures
- 06-03 History of ordered structures [Consider also classification numbers pertaining to Section 01]
- 06-04 Software, source code, etc. for problems pertaining to ordered structures
- 06-06 Proceedings, conferences, collections, etc. pertaining to ordered structures
- 06-08 Computational methods for problems pertaining to ordered structures
- 06-11 Research data for problems pertaining to ordered structures

## 06Axx Ordered sets

- 06A05 Total orders
- 06A06 Partial orders, general
- 06A07 Combinatorics of partially ordered sets
- 06A11 Algebraic aspects of posets
- 06A12 Semilattices [See also 20M10] {For topological semilattices, see 22A26}
- 06A15 Galois correspondences, closure operators (in relation to ordered sets)
- 06A75 Generalizations of ordered sets
- 06A99 None of the above, but in this section

## 06Bxx Lattices [See also 03G10]

- 06B05 Structure theory of lattices
- 06B10 Lattice ideals, congruence relations
- 06B15 Representation theory of lattices
- 06B20 Varieties of lattices
- 06B23 Complete lattices, completions
- 06B25 Free lattices, projective lattices, word problems [See also 03D40, 08A50, 20F10]
- 06B30 Topological lattices [See also 06F30, 22A26, 54F05, 54H12]
- 06B35 Continuous lattices and posets, applications [See also 06B30, 06D10, 06F30, 18B35, 22A26, 68Q55]
- 06B75 Generalizations of lattices
- 06B99 None of the above, but in this section

## 06Cxx Modular lattices, complemented lattices

- 06C05 Modular lattices, Desarguesian lattices
- 06C10 Semimodular lattices, geometric lattices
- 06C15 Complemented lattices, orthocomplemented lattices and posets [See also 03G12, 81P10]
- 06C20 Complemented modular lattices, continuous geometries
- 06C99 None of the above, but in this section

## 06Dxx Distributive lattices

- 06D05 Structure and representation theory of distributive lattices
- 06D10 Complete distributivity
- 06D15 Pseudocomplemented lattices
- 06D20 Heyting algebras (lattice-theoretic aspects) [See also 03G25]
- 06D22 Frames, locales {For topological questions, see 54-XX}
- 06D25 Post algebras (lattice-theoretic aspects) [See also 03G20]
- 06D30 De Morgan algebras, Łukasiewicz algebras (lattice-theoretic aspects) [See also 03G20]
- 06D35 MV-algebras
- 06D50 Lattices and duality
- 06D72 Fuzzy lattices (soft algebras) and related topics
- 06D75 Other generalizations of distributive lattices
- 06D99 None of the above, but in this section

## **06Exx Boolean algebras (Boolean rings)** [See also [03G05](#)]

- 06E05** Structure theory of Boolean algebras
- 06E10** Chain conditions, complete algebras
- 06E15** Stone spaces (Boolean spaces) and related structures
- 06E20** Ring-theoretic properties of Boolean algebras [See also [16E50](#), [16G30](#)]
- 06E25** Boolean algebras with additional operations (diagonalizable algebras, etc.) [See also [03G25](#), [03F45](#)]
- 06E30** Boolean functions [See also [94D10](#)]
- 06E75** Generalizations of Boolean algebras
- 06E99** None of the above, but in this section

## **06Fxx Ordered structures**

- 06F05** Ordered semigroups and monoids [See also [20Mxx](#)]
- 06F07** Quantales
- 06F10** Noether lattices
- 06F15** Ordered groups [See also [20F60](#)]
- 06F20** Ordered abelian groups, Riesz groups, ordered linear spaces [See also [46A40](#)]
- 06F25** Ordered rings, algebras, modules {For ordered fields, see [12J15](#)} [See also [13J25](#), [16W80](#)]
- 06F30** Ordered topological structures (aspects of ordered structures) [See also [06B30](#), [22A26](#), [54F05](#), [54H12](#)]
- 06F35** BCK-algebras, BCI-algebras (aspects of ordered structures) [See also [03G25](#)]
- 06F99** None of the above, but in this section

## **08-XX General algebraic systems**

- 08-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to general algebraic systems
- 08-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to general algebraic systems
- 08-02** Research exposition (monographs, survey articles) pertaining to general algebraic systems
- 08-03** History of general algebraic systems [Consider also classification numbers pertaining to [Section 01](#)]
- 08-04** Software, source code, etc. for problems pertaining to general algebraic systems
- 08-06** Proceedings, conferences, collections, etc. pertaining to general algebraic systems
- 08-08** Computational methods for problems pertaining to general algebraic systems
- 08-11** Research data for problems pertaining to general algebraic systems

## **08Axx Algebraic structures** [See also [03C05](#)]

- 08A02** Relational systems, laws of composition
- 08A05** Structure theory of algebraic structures
- 08A30** Subalgebras, congruence relations
- 08A35** Automorphisms and endomorphisms of algebraic structures
- 08A40** Operations and polynomials in algebraic structures, primal algebras
- 08A45** Equational compactness
- 08A50** Word problems (aspects of algebraic structures) [See also [03D40](#), [06B25](#), [20F10](#), [68R15](#)]
- 08A55** Partial algebras
- 08A60** Unary algebras
- 08A62** Finitary algebras
- 08A65** Infinitary algebras
- 08A68** Heterogeneous algebras
- 08A70** Applications of universal algebra in computer science
- 08A72** Fuzzy algebraic structures
- 08A99** None of the above, but in this section

## **08Bxx Varieties** [See also [03C05](#)]

- 08B05** Equational logic, Mal'tsev conditions
- 08B10** Congruence modularity, congruence distributivity
- 08B15** Lattices of varieties
- 08B20** Free algebras
- 08B25** Products, amalgamated products, and other kinds of limits and colimits [See also [18A30](#)]
- 08B26** Subdirect products and subdirect irreducibility
- 08B30** Injectives, projectives
- 08B99** None of the above, but in this section

## **08Cxx Other classes of algebras**

- 08C05** Categories of algebras [See also [18C05](#)]
- 08C10** Axiomatic model classes [See also [03Cxx](#), in particular [03C60](#)]
- 08C15** Quasivarieties
- 08C20** Natural dualities for classes of algebras [See also [06E15](#), [18A40](#), [22A30](#)]
- 08C99** None of the above, but in this section

## 11-XX Number theory

- 11-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to number theory
- 11-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to number theory
- 11-02 Research exposition (monographs, survey articles) pertaining to number theory
- 11-03 History of number theory [Consider also classification numbers pertaining to Section 01]
- 11-04 Software, source code, etc. for problems pertaining to number theory
- 11-06 Proceedings, conferences, collections, etc. pertaining to number theory
- 11-11 Research data for problems pertaining to number theory

### 11Axx Elementary number theory {For analogues in number fields, see 11R04}

- 11A05 Multiplicative structure; Euclidean algorithm; greatest common divisors
- 11A07 Congruences; primitive roots; residue systems
- 11A15 Power residues, reciprocity
- 11A25 Arithmetic functions; related numbers; inversion formulas
- 11A41 Primes
- 11A51 Factorization; primality
- 11A55 Continued fractions {For approximation results, see 11J70} [See also 11K50, 30B70, 40A15]
- 11A63 Radix representation; digital problems {For metric results, see 11K16}
- 11A67 Other number representations
- 11A99 None of the above, but in this section

### 11Bxx Sequences and sets

- 11B05 Density, gaps, topology
- 11B13 Additive bases, including sumsets [See also 05B10]
- 11B25 Arithmetic progressions [See also 11N13]
- 11B30 Arithmetic combinatorics; higher degree uniformity
- 11B34 Representation functions
- 11B37 Recurrences {For applications to special functions, see 33-XX}
- 11B39 Fibonacci and Lucas numbers and polynomials and generalizations
- 11B50 Sequences (mod  $m$ )
- 11B57 Farey sequences; the sequences  $1^k, 2^k, \dots$
- 11B65 Binomial coefficients; factorials;  $q$ -identities [See also 05A10, 05A30]

- 11B68 Bernoulli and Euler numbers and polynomials
- 11B73 Bell and Stirling numbers
- 11B75 Other combinatorial number theory
- 11B83 Special sequences and polynomials
- 11B85 Automata sequences
- 11B99 None of the above, but in this section

### 11Cxx Polynomials and matrices

- 11C08 Polynomials in number theory [See also 13F20]
- 11C20 Matrices, determinants in number theory [See also 15B36]
- 11C99 None of the above, but in this section

### 11Dxx Diophantine equations [See also 11Gxx, 14Gxx]

- 11D04 Linear Diophantine equations
- 11D07 The Frobenius problem
- 11D09 Quadratic and bilinear Diophantine equations
- 11D25 Cubic and quartic Diophantine equations
- 11D41 Higher degree equations; Fermat's equation
- 11D45 Counting solutions of Diophantine equations
- 11D57 Multiplicative and norm form equations
- 11D59 Thue-Mahler equations
- 11D61 Exponential Diophantine equations
- 11D68 Rational numbers as sums of fractions
- 11D72 Diophantine equations in many variables [See also 11P55]
- 11D75 Diophantine inequalities [See also 11J25]
- 11D79 Congruences in many variables
- 11D85 Representation problems [See also 11P55]
- 11D88  $p$ -adic and power series fields
- 11D99 None of the above, but in this section

### 11Exx Forms and linear algebraic groups [See also 19Gxx] {For quadratic forms in linear algebra, see 15A63}

- 11E04 Quadratic forms over general fields
- 11E08 Quadratic forms over local rings and fields
- 11E10 Forms over real fields
- 11E12 Quadratic forms over global rings and fields
- 11E16 General binary quadratic forms
- 11E20 General ternary and quaternary quadratic forms; forms of more than two variables
- 11E25 Sums of squares and representations by other particular quadratic forms
- 11E39 Bilinear and Hermitian forms
- 11E41 Class numbers of quadratic and Hermitian forms

- 11E45** Analytic theory (Epstein zeta functions; relations with automorphic forms and functions)
- 11E57** Classical groups [See also [14Lxx](#), [20Gxx](#)]
- 11E70**  $K$ -theory of quadratic and Hermitian forms
- 11E72** Galois cohomology of linear algebraic groups [See also [20G10](#)]
- 11E76** Forms of degree higher than two
- 11E81** Algebraic theory of quadratic forms; Witt groups and rings [See also [19G12](#), [19G24](#)]
- 11E88** Quadratic spaces; Clifford algebras [See also [15A63](#), [15A66](#)]
- 11E95**  $p$ -adic theory
- 11E99** None of the above, but in this section
- 11Fxx Discontinuous groups and automorphic forms** [See also [11R39](#), [11S37](#), [14Gxx](#), [14Kxx](#), [22E50](#), [22E55](#), [30F35](#), [32Nxx](#)] {For relations with quadratic forms, see [11E45](#)}
- 11F03** Modular and automorphic functions
- 11F06** Structure of modular groups and generalizations; arithmetic groups [See also [20H05](#), [20H10](#), [22E40](#)]
- 11F11** Holomorphic modular forms of integral weight
- 11F12** Automorphic forms, one variable
- 11F20** Dedekind eta function, Dedekind sums
- 11F22** Relationship to Lie algebras and finite simple groups
- 11F23** Relations with algebraic geometry and topology
- 11F25** Hecke-Petersson operators, differential operators (one variable)
- 11F27** Theta series; Weil representation; theta correspondences
- 11F30** Fourier coefficients of automorphic forms
- 11F32** Modular correspondences, etc.
- 11F33** Congruences for modular and  $p$ -adic modular forms [See also [14G20](#), [22E50](#)]
- 11F37** Forms of half-integer weight; nonholomorphic modular forms
- 11F41** Automorphic forms on  $GL(2)$ ; Hilbert and Hilbert-Siegel modular groups and their modular and automorphic forms; Hilbert modular surfaces [See also [14J20](#)]
- 11F46** Siegel modular groups; Siegel and Hilbert-Siegel modular and automorphic forms
- 11F50** Jacobi forms
- 11F52** Modular forms associated to Drinfel'd modules
- 11F55** Other groups and their modular and automorphic forms (several variables)
- 11F60** Hecke-Petersson operators, differential operators (several variables)
- 11F66** Langlands  $L$ -functions; one variable Dirichlet series and functional equations
- 11F67** Special values of automorphic  $L$ -series, periods of automorphic forms, cohomology, modular symbols
- 11F68** Dirichlet series in several complex variables associated to automorphic forms; Weyl group multiple Dirichlet series
- 11F70** Representation-theoretic methods; automorphic representations over local and global fields
- 11F72** Spectral theory; trace formulas (e.g., that of Selberg)
- 11F75** Cohomology of arithmetic groups
- 11F77** Automorphic forms and their relations with perfectoid spaces [See also [14G45](#)]
- 11F80** Galois representations
- 11F85**  $p$ -adic theory, local fields [See also [14G20](#), [22E50](#)]
- 11F99** None of the above, but in this section
- 11Gxx Arithmetic algebraic geometry (Diophantine geometry)** [See also [11Dxx](#), [14Gxx](#), [14Kxx](#)]
- 11G05** Elliptic curves over global fields [See also [14H52](#)]
- 11G07** Elliptic curves over local fields [See also [14G20](#), [14H52](#)]
- 11G09** Drinfel'd modules; higher-dimensional motives, etc. [See also [14L05](#)]
- 11G10** Abelian varieties of dimension  $> 1$  [See also [14Kxx](#)]
- 11G15** Complex multiplication and moduli of abelian varieties [See also [14K22](#)]
- 11G16** Elliptic and modular units [See also [11R27](#)]
- 11G18** Arithmetic aspects of modular and Shimura varieties [See also [14G35](#)]
- 11G20** Curves over finite and local fields [See also [14H25](#)]
- 11G25** Varieties over finite and local fields [See also [14G15](#), [14G20](#)]
- 11G30** Curves of arbitrary genus or genus  $\neq 1$  over global fields [See also [14H25](#)]
- 11G32** Arithmetic aspects of dessins d'enfants, Belyi theory
- 11G35** Varieties over global fields [See also [14G25](#)]
- 11G40**  $L$ -functions of varieties over global fields; Birch-Swinnerton-Dyer conjecture [See also [14G10](#)]
- 11G42** Arithmetic mirror symmetry [See also [14J33](#)]
- 11G45** Geometric class field theory [See also [11R37](#), [14C35](#), [19F05](#)]
- 11G50** Heights [See also [14G40](#), [37P30](#)]
- 11G55** Polylogarithms and relations with  $K$ -theory
- 11G99** None of the above, but in this section

## 11Hxx Geometry of numbers {For applications in coding theory, see [94B75](#)}

- 11H06 Lattices and convex bodies (number-theoretic aspects) [See also [11P21](#), [52C05](#), [52C07](#)]
- 11H16 Nonconvex bodies
- 11H31 Lattice packing and covering (number-theoretic aspects) [See also [05B40](#), [52C15](#), [52C17](#)]
- 11H46 Products of linear forms
- 11H50 Minima of forms
- 11H55 Quadratic forms (reduction theory, extreme forms, etc.)
- 11H56 Automorphism groups of lattices
- 11H60 Mean value and transfer theorems
- 11H71 Relations with coding theory
- 11H99 None of the above, but in this section

## 11Jxx Diophantine approximation, transcendental number theory [See also [11K60](#)]

- 11J04 Homogeneous approximation to one number
- 11J06 Markov and Lagrange spectra and generalizations
- 11J13 Simultaneous homogeneous approximation, linear forms
- 11J17 Approximation by numbers from a fixed field
- 11J20 Inhomogeneous linear forms
- 11J25 Diophantine inequalities [See also [11D75](#)]
- 11J54 Small fractional parts of polynomials and generalizations
- 11J61 Approximation in non-Archimedean valuations
- 11J68 Approximation to algebraic numbers
- 11J70 Continued fractions and generalizations [See also [11A55](#), [11K50](#)]
- 11J71 Distribution modulo one [See also [11K06](#)]
- 11J72 Irrationality; linear independence over a field
- 11J81 Transcendence (general theory)
- 11J82 Measures of irrationality and of transcendence
- 11J83 Metric theory
- 11J85 Algebraic independence; Gel'fond's method
- 11J86 Linear forms in logarithms; Baker's method
- 11J87 Schmidt Subspace Theorem and applications
- 11J89 Transcendence theory of elliptic and abelian functions
- 11J91 Transcendence theory of other special functions
- 11J93 Transcendence theory of Drinfel'd and  $t$ -modules
- 11J95 Results involving abelian varieties
- 11J97 Number-theoretic analogues of methods in Nevanlinna theory (work of Vojta et al.)
- 11J99 None of the above, but in this section

## 11Kxx Probabilistic theory: distribution modulo 1; metric theory of algorithms

- 11K06 General theory of distribution modulo 1 [See also [11J71](#)]
- 11K16 Normal numbers, radix expansions, Pisot numbers, Salem numbers, good lattice points, etc. [See also [11A63](#)]
- 11K31 Special sequences
- 11K36 Well-distributed sequences and other variations
- 11K38 Irregularities of distribution, discrepancy [See also [11Nxx](#)]
- 11K41 Continuous,  $p$ -adic and abstract analogues
- 11K45 Pseudo-random numbers; Monte Carlo methods [See also [65C05](#), [65C10](#)]
- 11K50 Metric theory of continued fractions [See also [11A55](#), [11J70](#)]
- 11K55 Metric theory of other algorithms and expansions; measure and Hausdorff dimension [See also [11N99](#), [28Dxx](#)]
- 11K60 Diophantine approximation in probabilistic number theory [See also [11Jxx](#)]
- 11K65 Arithmetic functions in probabilistic number theory [See also [11Nxx](#)]
- 11K70 Harmonic analysis and almost periodicity in probabilistic number theory
- 11K99 None of the above, but in this section

## 11Lxx Exponential sums and character sums {For finite fields, see [11Txx](#)}

- 11L03 Trigonometric and exponential sums, general
- 11L05 Gauss and Kloosterman sums; generalizations
- 11L07 Estimates on exponential sums
- 11L10 Jacobsthal and Brewer sums; other complete character sums
- 11L15 Weyl sums
- 11L20 Sums over primes
- 11L26 Sums over arbitrary intervals
- 11L40 Estimates on character sums
- 11L99 None of the above, but in this section



## 11Mxx Zeta and $L$ -functions: analytic theory

- 11M06  $\zeta(s)$  and  $L(s, \chi)$
- 11M20 Real zeros of  $L(s, \chi)$ ; results on  $L(1, \chi)$
- 11M26 Nonreal zeros of  $\zeta(s)$  and  $L(s, \chi)$ ; Riemann and other hypotheses
- 11M32 Multiple Dirichlet series and zeta functions and multizeta values
- 11M35 Hurwitz and Lerch zeta functions
- 11M36 Selberg zeta functions and regularized determinants; applications to spectral theory, Dirichlet series, Eisenstein series, etc. (explicit formulas)
- 11M38 Zeta and  $L$ -functions in characteristic  $p$
- 11M41 Other Dirichlet series and zeta functions {For local and global ground fields, see [11R42](#), [11R52](#), [11S40](#), [11S45](#); for algebro-geometric methods, see [14G10](#)} [See also [11E45](#), [11F66](#), [11F70](#), [11F72](#)]
- 11M45 Tauberian theorems [See also [40E05](#)]
- 11M50 Relations with random matrices
- 11M55 Relations with noncommutative geometry
- 11M99 None of the above, but in this section

## 11Nxx Multiplicative number theory

- 11N05 Distribution of primes
- 11N13 Primes in congruence classes
- 11N25 Distribution of integers with specified multiplicative constraints
- 11N30 Turán theory [See also [30Bxx](#)]
- 11N32 Primes represented by polynomials; other multiplicative structures of polynomial values
- 11N35 Sieves
- 11N36 Applications of sieve methods
- 11N37 Asymptotic results on arithmetic functions
- 11N45 Asymptotic results on counting functions for algebraic and topological structures
- 11N56 Rate of growth of arithmetic functions
- 11N60 Distribution functions associated with additive and positive multiplicative functions
- 11N64 Other results on the distribution of values or the characterization of arithmetic functions
- 11N69 Distribution of integers in special residue classes
- 11N75 Applications of automorphic functions and forms to multiplicative problems [See also [11Fxx](#)]
- 11N80 Generalized primes and integers
- 11N99 None of the above, but in this section

## 11Pxx Additive number theory; partitions

- 11P05 Waring's problem and variants
- 11P21 Lattice points in specified regions
- 11P32 Goldbach-type theorems; other additive questions involving primes
- 11P55 Applications of the Hardy-Littlewood method [See also [11D85](#)]
- 11P70 Inverse problems of additive number theory, including sumsets
- 11P81 Elementary theory of partitions [See also [05A17](#)]
- 11P82 Analytic theory of partitions
- 11P83 Partitions; congruences and congruential restrictions
- 11P84 Partition identities; identities of Rogers-Ramanujan type
- 11P99 None of the above, but in this section

## 11Rxx Algebraic number theory: global fields {For complex multiplication, see [11G15](#)}

- 11R04 Algebraic numbers; rings of algebraic integers
- 11R06 PV-numbers and generalizations; other special algebraic numbers; Mahler measure
- 11R09 Polynomials (irreducibility, etc.)
- 11R11 Quadratic extensions
- 11R16 Cubic and quartic extensions
- 11R18 Cyclotomic extensions
- 11R20 Other abelian and metabelian extensions
- 11R21 Other number fields
- 11R23 Iwasawa theory
- 11R27 Units and factorization
- 11R29 Class numbers, class groups, discriminants
- 11R32 Galois theory
- 11R33 Integral representations related to algebraic numbers; Galois module structure of rings of integers [See also [20C10](#)]
- 11R34 Galois cohomology [See also [12Gxx](#), [19A31](#)]
- 11R37 Class field theory
- 11R39 Langlands-Weil conjectures, nonabelian class field theory [See also [11Fxx](#), [22E55](#)]
- 11R42 Zeta functions and  $L$ -functions of number fields [See also [11M41](#), [19F27](#)]
- 11R44 Distribution of prime ideals [See also [11N05](#)]
- 11R45 Density theorems
- 11R47 Other analytic theory [See also [11Nxx](#)]
- 11R52 Quaternion and other division algebras: arithmetic, zeta functions

- 11R54 Other algebras and orders, and their zeta and  $L$ -functions [See also 11S45, 16Hxx, 16Kxx]
- 11R56 Adèle rings and groups
- 11R58 Arithmetic theory of algebraic function fields [See also 14-XX]
- 11R59 Zeta functions and  $L$ -functions of function fields
- 11R60 Cyclotomic function fields (class groups, Bernoulli objects, etc.)
- 11R65 Class groups and Picard groups of orders
- 11R70  $K$ -theory of global fields [See also 19Fxx]
- 11R80 Totally real fields [See also 12J15]
- 11R99 None of the above, but in this section

### 11Sxx Algebraic number theory: local and $p$ -adic fields

- 11S05 Polynomials
- 11S15 Ramification and extension theory
- 11S20 Galois theory
- 11S23 Integral representations
- 11S25 Galois cohomology [See also 12Gxx, 16H05]
- 11S31 Class field theory;  $p$ -adic formal groups [See also 14L05]
- 11S37 Langlands-Weil conjectures, nonabelian class field theory [See also 11Fxx, 22E50]
- 11S40 Zeta functions and  $L$ -functions [See also 11M41, 19F27]
- 11S45 Algebras and orders, and their zeta functions [See also 11R52, 11R54, 16Hxx, 16Kxx]
- 11S70  $K$ -theory of local fields [See also 19Fxx]
- 11S80 Other analytic theory (analogues of beta and gamma functions,  $p$ -adic integration, etc.)
- 11S82 Non-Archimedean dynamical systems [See mainly 37Pxx]
- 11S85 Other nonanalytic theory
- 11S90 Prehomogeneous vector spaces
- 11S99 None of the above, but in this section

### 11Txx Finite fields and commutative rings (number-theoretic aspects)

- 11T06 Polynomials over finite fields
- 11T22 Cyclotomy
- 11T23 Exponential sums
- 11T24 Other character sums and Gauss sums
- 11T30 Structure theory for finite fields and commutative rings, number-theoretic aspects
- 11T55 Arithmetic theory of polynomial rings over finite fields
- 11T60 Finite upper half-planes
- 11T71 Algebraic coding theory; cryptography (number-theoretic aspects)
- 11T99 None of the above, but in this section

### 11Uxx Connections of number theory and logic

- 11U05 Decidability (number-theoretic aspects) [See also 03B25]
- 11U07 Ultraproducts (number-theoretic aspects) [See also 03C20]
- 11U09 Model theory (number-theoretic aspects) [See also 03Cxx]
- 11U10 Nonstandard arithmetic (number-theoretic aspects) [See also 03H15]
- 11U99 None of the above, but in this section

### 11Yxx Computational number theory {For software etc., see 11-04}

- 11Y05 Factorization
- 11Y11 Primality
- 11Y16 Number-theoretic algorithms; complexity [See also 68Q25]
- 11Y35 Analytic computations
- 11Y40 Algebraic number theory computations
- 11Y50 Computer solution of Diophantine equations
- 11Y55 Calculation of integer sequences
- 11Y60 Evaluation of number-theoretic constants
- 11Y65 Continued fraction calculations (number-theoretic aspects)
- 11Y70 Values of arithmetic functions; tables
- 11Y99 None of the above, but in this section

### 11Zxx Miscellaneous applications of number theory

- 11Z05 Miscellaneous applications of number theory
- 11Z99 None of the above, but in this section

## 12-XX Field theory and polynomials

- 12-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to field theory
- 12-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to field theory
- 12-02 Research exposition (monographs, survey articles) pertaining to field theory
- 12-03 History of field theory [Consider also classification numbers pertaining to Section 01]
- 12-04 Software, source code, etc. for problems pertaining to field theory
- 12-06 Proceedings, conferences, collections, etc. pertaining to field theory



**12-08** Computational methods for problems pertaining to field theory

**12-11** Research data for problems pertaining to field theory

## **12Dxx Real and complex fields**

**12D05** Polynomials in real and complex fields: factorization

**12D10** Polynomials in real and complex fields: location of zeros (algebraic theorems) {For the analytic theory, see [26C10](#), [30C15](#)}

**12D15** Fields related with sums of squares (formally real fields, Pythagorean fields, etc.) [See also [11Exx](#)]

**12D99** None of the above, but in this section

## **12Exx General field theory**

**12E05** Polynomials in general fields (irreducibility, etc.)

**12E10** Special polynomials in general fields

**12E12** Equations in general fields

**12E15** Skew fields, division rings [See also [11R52](#), [11R54](#), [11S45](#), [16Kxx](#)]

**12E20** Finite fields (field-theoretic aspects)

**12E25** Hilbertian fields; Hilbert's irreducibility theorem

**12E30** Field arithmetic

**12E99** None of the above, but in this section

## **12Fxx Field extensions**

**12F05** Algebraic field extensions

**12F10** Separable extensions, Galois theory

**12F12** Inverse Galois theory

**12F15** Inseparable field extensions

**12F20** Transcendental field extensions

**12F99** None of the above, but in this section

## **12Gxx Homological methods (field theory)**

**12G05** Galois cohomology [See also [14F22](#), [16Hxx](#), [16K50](#)]

**12G10** Cohomological dimension of fields

**12G99** None of the above, but in this section

## **12Hxx Differential and difference algebra**

**12H05** Differential algebra [See also [13Nxx](#)]

**12H10** Difference algebra [See also [39Axx](#)]

**12H20** Abstract differential equations [See also [34Mxx](#)]

**12H25**  $p$ -adic differential equations [See also [11S80](#), [14G20](#)]

**12H99** None of the above, but in this section

## **12Jxx Topological fields**

**12J05** Normed fields

**12J10** Valued fields

**12J12** Formally  $p$ -adic fields

**12J15** Ordered fields

**12J17** Topological semifields

**12J20** General valuation theory for fields [See also [13A18](#)]

**12J25** Non-Archimedean valued fields [See also [30G06](#), [32P05](#), [46S10](#), [47S10](#)]

**12J27** Krasner-Tate algebras [See mainly [32P05](#); see also [46S10](#), [47S10](#)]

**12J99** None of the above, but in this section

## **12Kxx Generalizations of fields**

**12K05** Near-fields [See also [16Y30](#)]

**12K10** Semifields [See also [16Y60](#)]

**12K99** None of the above, but in this section

## **12Lxx Connections between field theory and logic**

**12L05** Decidability and field theory [See also [03B25](#)]

**12L10** Ultraproducts and field theory [See also [03C20](#)]

**12L12** Model theory of fields [See also [03C60](#)]

**12L15** Nonstandard arithmetic and field theory [See also [03H15](#)]

**12L99** None of the above, but in this section

## **13-XX Commutative algebra**

**13-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to commutative algebra

**13-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to commutative algebra

**13-02** Research exposition (monographs, survey articles) pertaining to commutative algebra

**13-03** History of commutative algebra [Consider also classification numbers pertaining to Section [01](#)]

**13-04** Software, source code, etc. for problems pertaining to commutative algebra

**13-06** Proceedings, conferences, collections, etc. pertaining to commutative algebra

**13-11** Research data for problems pertaining to commutative algebra

## 13Axx General commutative ring theory

- 13A02 Graded rings [See also 16W50]
- 13A05 Divisibility and factorizations in commutative rings [See also 13F15]
- 13A15 Ideals and multiplicative ideal theory in commutative rings
- 13A18 Valuations and their generalizations for commutative rings [See also 12J20]
- 13A30 Associated graded rings of ideals (Rees ring, form ring), analytic spread and related topics
- 13A35 Characteristic  $p$  methods (Frobenius endomorphism) and reduction to characteristic  $p$ ; tight closure [See also 13B22]
- 13A50 Actions of groups on commutative rings; invariant theory [See also 14L24]
- 13A70 General commutative ring theory and combinatorics (zero-divisor graphs, annihilating-ideal graphs, etc.) [See also 05C25, 05E40]
- 13A99 None of the above, but in this section

## 13Bxx Commutative ring extensions and related topics

- 13B02 Extension theory of commutative rings
- 13B05 Galois theory and commutative ring extensions
- 13B10 Morphisms of commutative rings
- 13B21 Integral dependence in commutative rings; going up, going down
- 13B22 Integral closure of commutative rings and ideals [See also 13A35]; integrally closed rings, related rings (Japanese, etc.)
- 13B25 Polynomials over commutative rings [See also 11C08, 11T06, 13F20, 13M10]
- 13B30 Rings of fractions and localization for commutative rings [See also 16S85]
- 13B35 Completion of commutative rings [See also 13J10]
- 13B40 Étale and flat extensions; Henselization; Artin approximation [See also 13J15, 14B12, 14B25]
- 13B99 None of the above, but in this section

## 13Cxx Theory of modules and ideals in commutative rings

- 13C05 Structure, classification theorems for modules and ideals in commutative rings
- 13C10 Projective and free modules and ideals in commutative rings [See also 19A13]
- 13C11 Injective and flat modules and ideals in commutative rings
- 13C12 Torsion modules and ideals in commutative rings

- 13C13 Other special types of modules and ideals in commutative rings
- 13C14 Cohen-Macaulay modules [See also 13H10]
- 13C15 Dimension theory, depth, related commutative rings (catenary, etc.)
- 13C20 Class groups [See also 11R29]
- 13C40 Linkage, complete intersections and determinantal ideals [See also 14M06, 14M10, 14M12]
- 13C60 Module categories and commutative rings
- 13C70 Theory of modules and ideals in commutative rings described by combinatorial properties [See also 05C25, 05E40]
- 13C99 None of the above, but in this section

## 13Dxx Homological methods in commutative ring theory {For noncommutative rings, see 16Exx; for general categories, see 18Gxx}

- 13D02 Syzygies, resolutions, complexes and commutative rings
- 13D03 (Co)homology of commutative rings and algebras (e.g., Hochschild, André-Quillen, cyclic, dihedral, etc.)
- 13D05 Homological dimension and commutative rings
- 13D07 Homological functors on modules of commutative rings (Tor, Ext, etc.)
- 13D09 Derived categories and commutative rings
- 13D10 Deformations and infinitesimal methods in commutative ring theory [See also 14B10, 14B12, 14D15, 32Gxx]
- 13D15 Grothendieck groups,  $K$ -theory and commutative rings [See also 14C35, 18F30, 19Axx, 19D50]
- 13D22 Homological conjectures (intersection theorems) in commutative ring theory
- 13D30 Torsion theory for commutative rings [See also 13C12, 18E40]
- 13D40 Hilbert-Samuel and Hilbert-Kunz functions; Poincaré series
- 13D45 Local cohomology and commutative rings [See also 14B15]
- 13D99 None of the above, but in this section

## 13Exx Chain conditions, finiteness conditions in commutative ring theory

- 13E05 Commutative Noetherian rings and modules
- 13E10 Commutative Artinian rings and modules, finite-dimensional algebras
- 13E15 Commutative rings and modules of finite generation or presentation; number of generators
- 13E99 None of the above, but in this section

## 13Fxx Arithmetic rings and other special commutative rings

- 13F05 Dedekind, Prüfer, Krull and Mori rings and their generalizations
- 13F07 Euclidean rings and generalizations
- 13F10 Principal ideal rings
- 13F15 Commutative rings defined by factorization properties (e.g., atomic, factorial, half-factorial) [See also 13A05, 14M05]
- 13F20 Polynomial rings and ideals; rings of integer-valued polynomials [See also 11C08, 13B25]
- 13F25 Formal power series rings [See also 13J05]
- 13F30 Valuation rings [See also 13A18]
- 13F35 Witt vectors and related rings
- 13F40 Excellent rings
- 13F45 Seminormal rings
- 13F50 Rings with straightening laws, Hodge algebras
- 13F55 Commutative rings defined by monomial ideals; Stanley-Reisner face rings; simplicial complexes [See also 55U10]
- 13F60 Cluster algebras
- 13F65 Commutative rings defined by binomial ideals, toric rings, etc. [See also 14M25]
- 13F70 Other commutative rings defined by combinatorial properties
- 13F99 None of the above, but in this section

## 13Gxx Integral domains

- 13G05 Integral domains
- 13G99 None of the above, but in this section

## 13Hxx Local rings and semilocal rings

- 13H05 Regular local rings
- 13H10 Special types (Cohen-Macaulay, Gorenstein, Buchsbaum, etc.) [See also 14M05]
- 13H15 Multiplicity theory and related topics [See also 14C17]
- 13H99 None of the above, but in this section

## 13Jxx Topological rings and modules [See also 16W60, 16W80]

- 13J05 Power series rings [See also 13F25]
- 13J07 Analytical algebras and rings [See also 32B05]
- 13J10 Complete rings, completion [See also 13B35]
- 13J15 Henselian rings [See also 13B40]
- 13J20 Global topological rings
- 13J25 Ordered rings [See also 06F25]
- 13J30 Real algebra [See also 12D15, 14Pxx]
- 13J99 None of the above, but in this section

## 13Lxx Applications of logic to commutative algebra [See also 03Cxx, 03Hxx]

- 13L05 Applications of logic to commutative algebra [See also 03Cxx, 03Hxx]
- 13L99 None of the above, but in this section

## 13Mxx Finite commutative rings {For number-theoretic aspects, see 11Txx}

- 13M05 Structure of finite commutative rings
- 13M10 Polynomials and finite commutative rings
- 13M99 None of the above, but in this section

## 13Nxx Differential algebra [See also 12H05, 14F10]

- 13N05 Modules of differentials
- 13N10 Commutative rings of differential operators and their modules [See also 16S32, 32C38]
- 13N15 Derivations and commutative rings
- 13N99 None of the above, but in this section

## 13Pxx Computational aspects and applications of commutative rings [See also 14Qxx, 68W30] {For software etc., see 13-04}

- 13P05 Polynomials, factorization in commutative rings [See also 12-08]
- 13P10 Gröbner bases; other bases for ideals and modules (e.g., Janet and border bases)
- 13P15 Solving polynomial systems; resultants
- 13P20 Computational homological algebra [See also 13Dxx]
- 13P25 Applications of commutative algebra (e.g., to statistics, control theory, optimization, etc.)
- 13P99 None of the above, but in this section

## 14-XX Algebraic geometry

- 14-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to algebraic geometry
- 14-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to algebraic geometry
- 14-02 Research exposition (monographs, survey articles) pertaining to algebraic geometry
- 14-03 History of algebraic geometry [Consider also classification numbers pertaining to Section 01]
- 14-04 Software, source code, etc. for problems pertaining to algebraic geometry
- 14-06 Proceedings, conferences, collections, etc. pertaining to algebraic geometry
- 14-11 Research data for problems pertaining to algebraic geometry

## 14Axx Foundations of algebraic geometry

- 14A05 Relevant commutative algebra [See also 13-XX]
- 14A10 Varieties and morphisms
- 14A15 Schemes and morphisms
- 14A20 Generalizations (algebraic spaces, stacks)
- 14A21 Logarithmic algebraic geometry, log schemes
- 14A22 Noncommutative algebraic geometry [See also 16S38]
- 14A23 Geometry over the field with one element
- 14A25 Elementary questions in algebraic geometry
- 14A30 Fundamental constructions in algebraic geometry involving higher and derived categories (homotopical algebraic geometry, derived algebraic geometry, etc.) {For categorical aspects, see 18Fxx, 18Gxx}
- 14A99 None of the above, but in this section

## 14Bxx Local theory in algebraic geometry

- 14B05 Singularities in algebraic geometry [See also 14E15, 14H20, 14J17, 32Sxx, 58Kxx]
- 14B07 Deformations of singularities [See also 14D15, 32S30]
- 14B10 Infinitesimal methods in algebraic geometry [See also 13D10]
- 14B12 Local deformation theory, Artin approximation, etc. [See also 13B40, 13D10]
- 14B15 Local cohomology and algebraic geometry [See also 13D45, 32C36]
- 14B20 Formal neighborhoods in algebraic geometry
- 14B25 Local structure of morphisms in algebraic geometry: étale, flat, etc. [See also 13B40]
- 14B99 None of the above, but in this section

## 14Cxx Cycles and subschemes

- 14C05 Parametrization (Chow and Hilbert schemes)
- 14C15 (Equivariant) Chow groups and rings; motives
- 14C17 Intersection theory, characteristic classes, intersection multiplicities in algebraic geometry [See also 13H15]
- 14C20 Divisors, linear systems, invertible sheaves
- 14C21 Pencils, nets, webs in algebraic geometry [See also 53A60]
- 14C22 Picard groups
- 14C25 Algebraic cycles
- 14C30 Transcendental methods, Hodge theory (algebraic-geometric aspects) [See also 14D07, 32G20, 32J25, 32S35], Hodge conjecture
- 14C34 Torelli problem [See also 32G20]
- 14C35 Applications of methods of algebraic  $K$ -theory in algebraic geometry [See also 19Exx]
- 14C40 Riemann-Roch theorems [See also 19E20, 19L10]
- 14C99 None of the above, but in this section

## 14Dxx Families, fibrations in algebraic geometry

- 14D05 Structure of families (Picard-Lefschetz, monodromy, etc.)
- 14D06 Fibrations, degenerations in algebraic geometry
- 14D07 Variation of Hodge structures (algebraic-geometric aspects) [See also 32G20]
- 14D10 Arithmetic ground fields (finite, local, global) and families or fibrations
- 14D15 Formal methods and deformations in algebraic geometry [See also 13D10, 14B07, 32Gxx]
- 14D20 Algebraic moduli problems, moduli of vector bundles {For analytic moduli problems, see 32G13}
- 14D21 Applications of vector bundles and moduli spaces in mathematical physics (twistor theory, instantons, quantum field theory) [See also 32L25, 81Txx]
- 14D22 Fine and coarse moduli spaces
- 14D23 Stacks and moduli problems
- 14D24 Geometric Langlands program (algebraic-geometric aspects) [See also 22E57]
- 14D99 None of the above, but in this section

## 14Exx Birational geometry

- 14E05 Rational and birational maps
- 14E07 Birational automorphisms, Cremona group and generalizations
- 14E08 Rationality questions in algebraic geometry [See also 14M20]
- 14E15 Global theory and resolution of singularities (algebraic-geometric aspects) [See also 14B05, 32S20, 32S45]
- 14E16 McKay correspondence
- 14E18 Arcs and motivic integration
- 14E20 Coverings in algebraic geometry [See also 14H30]
- 14E22 Ramification problems in algebraic geometry [See also 11S15]
- 14E25 Embeddings in algebraic geometry
- 14E30 Minimal model program (Mori theory, extremal rays)
- 14E99 None of the above, but in this section

## 14Fxx (Co)homology theory in algebraic geometry [See also 13Dxx]

- 14F06 Sheaves in algebraic geometry [See also 14F07, 14H60, 14J60, 18F20, 32Lxx, 46M20]
- 14F07 Derived categories of sheaves, dg categories, and related constructions in algebraic geometry [See also 14A30, 14F06, 18Gxx]
- 14F10 Differentials and other special sheaves; D-modules; Bernstein-Sato ideals and polynomials [See also 13Nxx, 32C38]
- 14F17 Vanishing theorems in algebraic geometry [See also 32L20]
- 14F18 Multiplier ideals
- 14F20 Étale and other Grothendieck topologies and (co)homologies
- 14F22 Brauer groups of schemes [See also 12G05, 16K50]
- 14F25 Classical real and complex (co)homology in algebraic geometry
- 14F30  $p$ -adic cohomology, crystalline cohomology
- 14F35 Homotopy theory and fundamental groups in algebraic geometry [See also 14H30]
- 14F40 de Rham cohomology and algebraic geometry [See also 14C30, 32C35, 32L10]
- 14F42 Motivic cohomology; motivic homotopy theory [See also 19E15]
- 14F43 Other algebro-geometric (co)homologies (e.g., intersection, equivariant, Lawson, Deligne (co)homologies)
- 14F45 Topological properties in algebraic geometry
- 14F99 None of the above, but in this section

## 14Gxx Arithmetic problems in algebraic geometry; Diophantine geometry [See also 11Dxx, 11Gxx]

- 14G05 Rational points
- 14G10 Zeta functions and related questions in algebraic geometry (e.g., Birch-Swinnerton-Dyer conjecture) [See also 11G40]
- 14G12 Hasse principle, weak and strong approximation, Brauer-Manin obstruction [See also 14F22]
- 14G15 Finite ground fields in algebraic geometry
- 14G17 Positive characteristic ground fields in algebraic geometry
- 14G20 Local ground fields in algebraic geometry
- 14G22 Rigid analytic geometry
- 14G25 Global ground fields in algebraic geometry
- 14G27 Other nonalgebraically closed ground fields in algebraic geometry
- 14G32 Universal profinite groups (relationship to moduli spaces, projective and moduli towers, Galois theory)

- 14G35 Modular and Shimura varieties [See also 11F41, 11F46, 11G18]
- 14G40 Arithmetic varieties and schemes; Arakelov theory; heights [See also 11G50, 37P30]
- 14G45 Perfectoid spaces and mixed characteristic
- 14G50 Applications to coding theory and cryptography of arithmetic geometry [See also 94A60, 94B27, 94B40]
- 14G99 None of the above, but in this section

## 14Hxx Curves in algebraic geometry

- 14H05 Algebraic functions and function fields in algebraic geometry [See also 11R58]
- 14H10 Families, moduli of curves (algebraic)
- 14H15 Families, moduli of curves (analytic) [See also 30F10, 32G15]
- 14H20 Singularities of curves, local rings [See also 13Hxx, 14B05]
- 14H25 Arithmetic ground fields for curves [See also 11Dxx, 11G05, 14Gxx]
- 14H30 Coverings of curves, fundamental group [See also 14E20, 14F35]
- 14H37 Automorphisms of curves
- 14H40 Jacobians, Prym varieties [See also 32G20]
- 14H42 Theta functions and curves; Schottky problem [See also 14K25, 32G20]
- 14H45 Special algebraic curves and curves of low genus
- 14H50 Plane and space curves
- 14H51 Special divisors on curves (gonality, Brill-Noether theory)
- 14H52 Elliptic curves [See also 11G05, 11G07, 14Kxx]
- 14H55 Riemann surfaces; Weierstrass points; gap sequences [See also 30Fxx]
- 14H57 Dessins d'enfants theory {For arithmetic aspects, see 11G32}
- 14H60 Vector bundles on curves and their moduli [See also 14D20, 14F06, 14J60]
- 14H70 Relationships between algebraic curves and integrable systems
- 14H81 Relationships between algebraic curves and physics
- 14H99 None of the above, but in this section



## 14Jxx Surfaces and higher-dimensional varieties {For analytic theory, see 32Jxx}

- 14J10 Families, moduli, classification: algebraic theory
- 14J15 Moduli, classification: analytic theory; relations with modular forms [See also 32G13]
- 14J17 Singularities of surfaces or higher-dimensional varieties [See also 14B05, 14E15, 32S05, 32S25]
- 14J20 Arithmetic ground fields for surfaces or higher-dimensional varieties [See also 11Dxx, 11G25, 11G35, 14Gxx]
- 14J25 Special surfaces {For Hilbert modular surfaces, see 14G35}
- 14J26 Rational and ruled surfaces
- 14J27 Elliptic surfaces, elliptic or Calabi-Yau fibrations
- 14J28  $K3$  surfaces and Enriques surfaces
- 14J29 Surfaces of general type
- 14J30 3-folds
- 14J32 Calabi-Yau manifolds (algebraic-geometric aspects) [See also 32Q25]
- 14J33 Mirror symmetry (algebraic-geometric aspects) [See also 11G42, 53D37]
- 14J35 4-folds
- 14J40  $n$ -folds ( $n > 4$ )
- 14J42 Holomorphic symplectic varieties, hyper-Kähler varieties
- 14J45 Fano varieties
- 14J50 Automorphisms of surfaces and higher-dimensional varieties
- 14J60 Vector bundles on surfaces and higher-dimensional varieties, and their moduli [See also 14D20, 14F06, 14H60, 32Lxx]
- 14J70 Hypersurfaces and algebraic geometry
- 14J80 Topology of surfaces (Donaldson polynomials, Seiberg-Witten invariants)
- 14J81 Relationships with physics
- 14J99 None of the above, but in this section

## 14Kxx Abelian varieties and schemes

- 14K02 Isogeny
- 14K05 Algebraic theory of abelian varieties
- 14K10 Algebraic moduli of abelian varieties, classification [See also 11G15]
- 14K12 Subvarieties of abelian varieties
- 14K15 Arithmetic ground fields for abelian varieties [See also 11Dxx, 11Fxx, 11G10, 14Gxx]
- 14K20 Analytic theory of abelian varieties; abelian integrals and differentials

- 14K22 Complex multiplication and abelian varieties [See also 11G15]
- 14K25 Theta functions and abelian varieties [See also 14H42]
- 14K30 Picard schemes, higher Jacobians [See also 14H40, 32G20]
- 14K99 None of the above, but in this section

## 14Lxx Algebraic groups {For linear algebraic groups, see 20Gxx; for Lie algebras, see 17B45}

- 14L05 Formal groups,  $p$ -divisible groups [See also 55N22]
- 14L10 Group varieties
- 14L15 Group schemes
- 14L17 Affine algebraic groups, hyperalgebra constructions [See also 17B45, 18C40]
- 14L24 Geometric invariant theory [See also 13A50]
- 14L30 Group actions on varieties or schemes (quotients) [See also 13A50, 14L24, 14M17]
- 14L35 Classical groups (algebraic-geometric aspects) [See also 20Gxx, 51N30]
- 14L40 Other algebraic groups (geometric aspects)
- 14L99 None of the above, but in this section

## 14Mxx Special varieties

- 14M05 Varieties defined by ring conditions (factorial, Cohen-Macaulay, seminormal) [See also 13F15, 13F45, 13H10]
- 14M06 Linkage [See also 13C40]
- 14M07 Low codimension problems in algebraic geometry
- 14M10 Complete intersections [See also 13C40]
- 14M12 Determinantal varieties [See also 13C40]
- 14M15 Grassmannians, Schubert varieties, flag manifolds [See also 32M10, 51M35]
- 14M17 Homogeneous spaces and generalizations [See also 32M10, 53C30, 57T15]
- 14M20 Rational and unirational varieties [See also 14E08]
- 14M22 Rationally connected varieties
- 14M25 Toric varieties, Newton polyhedra, Okounkov bodies [See also 52B20]
- 14M27 Compactifications; symmetric and spherical varieties
- 14M30 Supervarieties [See also 32C11, 58A50]
- 14M35 Character varieties
- 14M99 None of the above, but in this section

## **14Nxx Projective and enumerative algebraic geometry [See also 51-XX]**

- 14N05** Projective techniques in algebraic geometry [See also [51N35](#)]
- 14N07** Secant varieties, tensor rank, varieties of sums of powers
- 14N10** Enumerative problems (combinatorial problems) in algebraic geometry
- 14N15** Classical problems, Schubert calculus
- 14N20** Configurations and arrangements of linear subspaces
- 14N25** Varieties of low degree
- 14N30** Adjunction problems
- 14N35** Gromov-Witten invariants, quantum cohomology, Gopakumar-Vafa invariants, Donaldson-Thomas invariants (algebraic-geometric aspects) [See also [53D45](#)]
- 14N99** None of the above, but in this section

## **14Pxx Real algebraic and real-analytic geometry**

- 14P05** Real algebraic sets [See also [12D15](#), [13J30](#)]
- 14P10** Semialgebraic sets and related spaces
- 14P15** Real-analytic and semi-analytic sets [See also [32B20](#), [32C05](#)]
- 14P20** Nash functions and manifolds [See also [32C07](#), [58A07](#)]
- 14P25** Topology of real algebraic varieties
- 14P99** None of the above, but in this section

## **14Qxx Computational aspects in algebraic geometry {For software etc., see 14-04} [See also 12-08, 13Pxx, 68W30]**

- 14Q05** Computational aspects of algebraic curves [See also [14Hxx](#)]
- 14Q10** Computational aspects of algebraic surfaces [See also [14Jxx](#)]
- 14Q15** Computational aspects of higher-dimensional varieties [See also [14Jxx](#), [14Mxx](#)]
- 14Q20** Effectivity, complexity and computational aspects of algebraic geometry
- 14Q25** Computational algebraic geometry over arithmetic ground fields [See also [14Gxx](#), [14H25](#), [14Kxx](#)]
- 14Q30** Computational real algebraic geometry [See also [14Pxx](#)]
- 14Q65** Geometric aspects of numerical algebraic geometry [See also [65H14](#)]
- 14Q99** None of the above, but in this section

## **14Rxx Affine geometry**

- 14R05** Classification of affine varieties
- 14R10** Affine spaces (automorphisms, embeddings, exotic structures, cancellation problem)
- 14R15** Jacobian problem [See also [13F20](#)]
- 14R20** Group actions on affine varieties [See also [13A50](#), [14L30](#)]
- 14R25** Affine fibrations [See also [14D06](#)]
- 14R99** None of the above, but in this section

## **14Txx Tropical geometry [See also 12K10, 14M25, 14N10, 52B20]**

- 14T10** Foundations of tropical geometry and relations with algebra {For algebraic aspects, see [15A80](#)}
- 14T15** Combinatorial aspects of tropical varieties
- 14T20** Geometric aspects of tropical varieties
- 14T25** Arithmetic aspects of tropical varieties
- 14T90** Applications of tropical geometry
- 14T99** None of the above, but in this section

## **15-XX Linear and multilinear algebra; matrix theory**

- 15-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to linear algebra
- 15-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to linear algebra
- 15-02** Research exposition (monographs, survey articles) pertaining to linear algebra
- 15-03** History of linear algebra [Consider also classification numbers pertaining to [Section 01](#)]
- 15-04** Software, source code, etc. for problems pertaining to linear algebra
- 15-06** Proceedings, conferences, collections, etc. pertaining to linear algebra
- 15-11** Research data for problems pertaining to linear algebra

## **15Axx Basic linear algebra**

- 15A03** Vector spaces, linear dependence, rank, lineability
- 15A04** Linear transformations, semilinear transformations
- 15A06** Linear equations (linear algebraic aspects)
- 15A09** Theory of matrix inversion and generalized inverses
- 15A10** Applications of generalized inverses
- 15A12** Conditioning of matrices [See also [65F35](#)]
- 15A15** Determinants, permanents, traces, other special matrix functions [See also [19B10](#), [19B14](#)]
- 15A16** Matrix exponential and similar functions of matrices
- 15A18** Eigenvalues, singular values, and eigenvectors
- 15A20** Diagonalization, Jordan forms
- 15A21** Canonical forms, reductions, classification



- 15A22 Matrix pencils [See also [47A56](#)]
- 15A23 Factorization of matrices
- 15A24 Matrix equations and identities
- 15A27 Commutativity of matrices
- 15A29 Inverse problems in linear algebra
- 15A30 Algebraic systems of matrices [See also [16S50](#), [20Gxx](#), [20Hxx](#)]
- 15A39 Linear inequalities of matrices
- 15A42 Inequalities involving eigenvalues and eigenvectors
- 15A45 Miscellaneous inequalities involving matrices
- 15A54 Matrices over function rings in one or more variables
- 15A60 Norms of matrices, numerical range, applications of functional analysis to matrix theory [See also [65F35](#), [65J05](#)]
- 15A63 Quadratic and bilinear forms, inner products [See mainly [11Exx](#)]
- 15A66 Clifford algebras, spinors
- 15A67 Applications of Clifford algebras to physics, etc.
- 15A69 Multilinear algebra, tensor calculus
- 15A72 Vector and tensor algebra, theory of invariants [See also [13A50](#), [14L24](#)]
- 15A75 Exterior algebra, Grassmann algebras
- 15A78 Other algebras built from modules
- 15A80 Max-plus and related algebras
- 15A83 Matrix completion problems
- 15A86 Linear preserver problems
- 15A99 None of the above, but in this section

### 15Bxx Special matrices

- 15B05 Toeplitz, Cauchy, and related matrices
- 15B10 Orthogonal matrices
- 15B15 Fuzzy matrices
- 15B30 Matrix Lie algebras
- 15B33 Matrices over special rings (quaternions, finite fields, etc.)
- 15B34 Boolean and Hadamard matrices
- 15B35 Sign pattern matrices
- 15B36 Matrices of integers [See also [11C20](#)]
- 15B48 Positive matrices and their generalizations; cones of matrices
- 15B51 Stochastic matrices
- 15B52 Random matrices (algebraic aspects) {For probabilistic aspects, see [60B20](#)}
- 15B57 Hermitian, skew-Hermitian, and related matrices
- 15B99 None of the above, but in this section

## 16-XX Associative rings and algebras {For the commutative case, see [13-XX](#)}

- 16-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to associative rings and algebras
- 16-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to associative rings and algebras
- 16-02 Research exposition (monographs, survey articles) pertaining to associative rings and algebras
- 16-03 History of associative rings and algebras [Consider also classification numbers pertaining to [Section 01](#)]
- 16-04 Software, source code, etc. for problems pertaining to associative rings and algebras
- 16-06 Proceedings, conferences, collections, etc. pertaining to associative rings and algebras
- 16-11 Research data for problems pertaining to associative rings and algebras

### 16Bxx General and miscellaneous

- 16B50 Category-theoretic methods and results in associative algebras (except as in [16D90](#)) [See also [18-XX](#)]
- 16B70 Applications of logic in associative algebras [See also [03Cxx](#)]
- 16B99 None of the above, but in this section

### 16Dxx Modules, bimodules and ideals in associative algebras

- 16D10 General module theory in associative algebras
- 16D20 Bimodules in associative algebras
- 16D25 Ideals in associative algebras
- 16D30 Infinite-dimensional simple rings (except as in [16Kxx](#))
- 16D40 Free, projective, and flat modules and ideals in associative algebras [See also [19A13](#)]
- 16D50 Injective modules, self-injective associative rings [See also [16L60](#)]
- 16D60 Simple and semisimple modules, primitive rings and ideals in associative algebras
- 16D70 Structure and classification for modules, bimodules and ideals (except as in [16Gxx](#)), direct sum decomposition and cancellation in associative algebras
- 16D80 Other classes of modules and ideals in associative algebras [See also [16G50](#)]
- 16D90 Module categories in associative algebras [See also [16Gxx](#), [16S90](#)]; module theory in a category-theoretic context; Morita equivalence and duality
- 16D99 None of the above, but in this section

- 16Exx Homological methods in associative algebras** {For commutative rings, see [13Dxx](#); for general categories, see [18Gxx](#)}
- 16E05** Syzygies, resolutions, complexes in associative algebras
- 16E10** Homological dimension in associative algebras
- 16E20** Grothendieck groups,  $K$ -theory, etc. [See also [18F30](#), [19Axx](#), [19D50](#)]
- 16E30** Homological functors on modules (Tor, Ext, etc.) in associative algebras
- 16E35** Derived categories and associative algebras
- 16E40** (Co)homology of rings and associative algebras (e.g., Hochschild, cyclic, dihedral, etc.)
- 16E45** Differential graded algebras and applications (associative algebraic aspects)
- 16E50** von Neumann regular rings and generalizations (associative algebraic aspects)
- 16E60** Semihereditary and hereditary rings, free ideal rings, Sylvester rings, etc.
- 16E65** Homological conditions on associative rings (generalizations of regular, Gorenstein, Cohen-Macaulay rings, etc.)
- 16E99** None of the above, but in this section
- 16Gxx Representation theory of associative rings and algebras**
- 16G10** Representations of associative Artinian rings
- 16G20** Representations of quivers and partially ordered sets
- 16G30** Representations of orders, lattices, algebras over commutative rings [See also [16Hxx](#)]
- 16G50** Cohen-Macaulay modules in associative algebras
- 16G60** Representation type (finite, tame, wild, etc.) of associative algebras
- 16G70** Auslander-Reiten sequences (almost split sequences) and Auslander-Reiten quivers
- 16G99** None of the above, but in this section
- 16Hxx Associative algebras and orders** {For arithmetic aspects, see [11R52](#), [11R54](#), [11S45](#); for representation theory, see [16G30](#)}
- 16H05** Separable algebras (e.g., quaternion algebras, Azumaya algebras, etc.)
- 16H10** Orders in separable algebras
- 16H15** Commutative orders
- 16H20** Lattices over orders
- 16H99** None of the above, but in this section
- 16Kxx Division rings and semisimple Artin rings** [See also [12E15](#), [15A30](#)]
- 16K20** Finite-dimensional division rings {For crossed products, see [16S35](#)}
- 16K40** Infinite-dimensional and general division rings
- 16K50** Brauer groups (algebraic aspects) [See also [12G05](#), [14F22](#)]
- 16K99** None of the above, but in this section
- 16Lxx Local rings and generalizations**
- 16L30** Noncommutative local and semilocal rings, perfect rings
- 16L60** Quasi-Frobenius rings [See also [16D50](#)]
- 16L99** None of the above, but in this section
- 16Nxx Radicals and radical properties of associative rings**
- 16N20** Jacobson radical, quasimultiplication
- 16N40** Nil and nilpotent radicals, sets, ideals, associative rings
- 16N60** Prime and semiprime associative rings [See also [16D60](#), [16U10](#)]
- 16N80** General radicals and associative rings {For radicals in module categories, see [16S90](#)}
- 16N99** None of the above, but in this section
- 16Pxx Chain conditions, growth conditions, and other forms of finiteness for associative rings and algebras**
- 16P10** Finite rings and finite-dimensional associative algebras {For semisimple, see [16K20](#); for commutative, see [11Txx](#), [13Mxx](#)}
- 16P20** Artinian rings and modules (associative rings and algebras)
- 16P40** Noetherian rings and modules (associative rings and algebras)
- 16P50** Localization and associative Noetherian rings [See also [16U20](#)]
- 16P60** Chain conditions on annihilators and summands: Goldie-type conditions [See also [16U20](#)], Krull dimension (associative rings and algebras)
- 16P70** Chain conditions on other classes of submodules, ideals, subrings, etc.; coherence (associative rings and algebras)
- 16P90** Growth rate, Gelfand-Kirillov dimension
- 16P99** None of the above, but in this section

## 16Rxx Rings with polynomial identity

- 16R10  $T$ -ideals, identities, varieties of associative rings and algebras
- 16R20 Semiprime p.i. rings, rings embeddable in matrices over commutative rings
- 16R30 Trace rings and invariant theory (associative rings and algebras)
- 16R40 Identities other than those of matrices over commutative rings
- 16R50 Other kinds of identities (generalized polynomial, rational, involution)
- 16R60 Functional identities (associative rings and algebras)
- 16R99 None of the above, but in this section

## 16Sxx Associative rings and algebras arising under various constructions

- 16S10 Associative rings determined by universal properties (free algebras, coproducts, adjunction of inverses, etc.)
- 16S15 Finite generation, finite presentability, normal forms (diamond lemma, term-rewriting)
- 16S20 Centralizing and normalizing extensions
- 16S30 Universal enveloping algebras of Lie algebras [See mainly 17B35]
- 16S32 Rings of differential operators (associative algebraic aspects) [See also 13N10, 32C38]
- 16S34 Group rings [See also 20C05, 20C07], Laurent polynomial rings (associative algebraic aspects)
- 16S35 Twisted and skew group rings, crossed products
- 16S36 Ordinary and skew polynomial rings and semigroup rings [See also 20M25]
- 16S37 Quadratic and Koszul algebras
- 16S38 Rings arising from noncommutative algebraic geometry [See also 14A22]
- 16S40 Smash products of general Hopf actions [See also 16T05]
- 16S50 Endomorphism rings; matrix rings [See also 15-XX]
- 16S60 Associative rings of functions, subdirect products, sheaves of rings
- 16S70 Extensions of associative rings by ideals
- 16S80 Deformations of associative rings [See also 13D10, 14D15]
- 16S85 Associative rings of fractions and localizations [See also 13B30]
- 16S88 Leavitt path algebras
- 16S90 Torsion theories; radicals on module categories (associative algebraic aspects) [See also 13D30, 18E40] {For radicals of rings, see 16Nxx}
- 16S99 None of the above, but in this section

## 16Txx Hopf algebras, quantum groups and related topics

- 16T05 Hopf algebras and their applications [See also 16S40, 57T05]
- 16T10 Bialgebras
- 16T15 Coalgebras and comodules; corings
- 16T20 Ring-theoretic aspects of quantum groups [See also 17B37, 20G42, 81R50]
- 16T25 Yang-Baxter equations
- 16T30 Connections of associative rings and algebras with combinatorics
- 16T99 None of the above, but in this section

## 16Uxx Conditions on elements

- 16U10 Integral domains (associative rings and algebras)
- 16U20 Ore rings, multiplicative sets, Ore localization
- 16U30 Divisibility, noncommutative UFDs
- 16U40 Idempotent elements
- 16U50 Generalized inverses
- 16U60 Units, groups of units (associative rings and algebras)
- 16U70 Center, normalizer (invariant elements) (associative rings and algebras)
- 16U80 Generalizations of commutativity (associative rings and algebras)
- 16U99 None of the above, but in this section

## 16Wxx Associative rings and algebras with additional structure

- 16W10 Rings with involution; Lie, Jordan and other nonassociative structures [See also 17B60, 17C50, 46Kxx]
- 16W20 Automorphisms and endomorphisms
- 16W22 Actions of groups and semigroups; invariant theory (associative rings and algebras)
- 16W25 Derivations, actions of Lie algebras
- 16W50 Graded rings and modules (associative rings and algebras)
- 16W55 “Super” (or “skew”) structure [See also 17A70, 17Bxx, 17C70] {For exterior algebras, see 15A75; for Clifford algebras, see 11E88, 15A66}
- 16W60 Valuations, completions, formal power series and related constructions (associative rings and algebras) [See also 13Jxx]
- 16W70 Filtered associative rings; filtrational and graded techniques
- 16W80 Topological and ordered rings and modules [See also 06F25, 13Jxx]
- 16W99 None of the above, but in this section

## **16Yxx Generalizations {For nonassociative rings, see 17-XX}**

- 16Y20 Hyperrings
- 16Y30 Near-rings [See also 12K05]
- 16Y60 Semirings [See also 12K10]
- 16Y80  $\Gamma$  and fuzzy structures
- 16Y99 None of the above, but in this section

## **16Zxx Computational aspects of associative rings {For software etc., see 16-04}**

- 16Z05 Computational aspects of associative rings [See also 68W30]
- 16Z10 Gröbner-Shirshov bases
- 16Z99 None of the above, but in this section

## **17-XX Nonassociative rings and algebras**

- 17-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to nonassociative rings and algebras
- 17-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to nonassociative rings and algebras
- 17-02 Research exposition (monographs, survey articles) pertaining to nonassociative rings and algebras
- 17-03 History of nonassociative rings and algebras [Consider also classification numbers pertaining to Section 01]
- 17-04 Software, source code, etc. for problems pertaining to nonassociative rings and algebras
- 17-06 Proceedings, conferences, collections, etc. pertaining to nonassociative rings and algebras
- 17-08 Computational methods for problems pertaining to nonassociative rings and algebras
- 17-11 Research data for problems pertaining to nonassociative rings and algebras

### **17Axx General nonassociative rings**

- 17A01 General theory of nonassociative rings and algebras
- 17A05 Power-associative rings
- 17A15 Noncommutative Jordan algebras
- 17A20 Flexible algebras
- 17A30 Nonassociative algebras satisfying other identities
- 17A32 Leibniz algebras
- 17A35 Nonassociative division algebras
- 17A36 Automorphisms, derivations, other operators (nonassociative rings and algebras)
- 17A40 Ternary compositions

- 17A42 Other  $n$ -ary compositions ( $n \geq 3$ )
- 17A45 Quadratic algebras (but not quadratic Jordan algebras)
- 17A50 Free nonassociative algebras
- 17A60 Structure theory for nonassociative algebras
- 17A61 Gröbner-Shirshov bases in nonassociative algebras
- 17A65 Radical theory (nonassociative rings and algebras)
- 17A70 Superalgebras
- 17A75 Composition algebras
- 17A80 Valued algebras
- 17A99 None of the above, but in this section

### **17Bxx Lie algebras and Lie superalgebras {For Lie groups, see 22Exx}**

- 17B01 Identities, free Lie (super)algebras
- 17B05 Structure theory for Lie algebras and superalgebras
- 17B08 Coadjoint orbits; nilpotent varieties
- 17B10 Representations of Lie algebras and Lie superalgebras, algebraic theory (weights)
- 17B15 Representations of Lie algebras and Lie superalgebras, analytic theory
- 17B20 Simple, semisimple, reductive (super)algebras
- 17B22 Root systems
- 17B25 Exceptional (super)algebras
- 17B30 Solvable, nilpotent (super)algebras
- 17B35 Universal enveloping (super)algebras [See also 16S30]
- 17B37 Quantum groups (quantized enveloping algebras) and related deformations [See also 16T20, 20G42, 81R50, 82B23]
- 17B38 Yang-Baxter equations and Rota-Baxter operators
- 17B40 Automorphisms, derivations, other operators for Lie algebras and super algebras
- 17B45 Lie algebras of linear algebraic groups [See also 14Lxx and 20Gxx]
- 17B50 Modular Lie (super)algebras
- 17B55 Homological methods in Lie (super)algebras
- 17B56 Cohomology of Lie (super)algebras
- 17B60 Lie (super)algebras associated with other structures (associative, Jordan, etc.) [See also 16W10, 17C40, 17C50]
- 17B61 Hom-Lie and related algebras
- 17B62 Lie bialgebras; Lie coalgebras
- 17B63 Poisson algebras
- 17B65 Infinite-dimensional Lie (super)algebras [See also 22E65]
- 17B66 Lie algebras of vector fields and related (super) algebras
- 17B67 Kac-Moody (super)algebras; extended affine Lie algebras; toroidal Lie algebras

- 17B68 Virasoro and related algebras
- 17B69 Vertex operators; vertex operator algebras and related structures
- 17B70 Graded Lie (super)algebras
- 17B75 Color Lie (super)algebras
- 17B80 Applications of Lie algebras and superalgebras to integrable systems
- 17B81 Applications of Lie (super)algebras to physics, etc.
- 17B99 None of the above, but in this section

### 17Cxx Jordan algebras (algebras, triples and pairs)

- 17C05 Identities and free Jordan structures
- 17C10 Structure theory for Jordan algebras
- 17C17 Radicals in Jordan algebras
- 17C20 Simple, semisimple Jordan algebras
- 17C27 Idempotents, Peirce decompositions
- 17C30 Associated groups, automorphisms of Jordan algebras
- 17C36 Associated manifolds of Jordan algebras
- 17C37 Associated geometries of Jordan algebras
- 17C40 Exceptional Jordan structures
- 17C50 Jordan structures associated with other structures [See also 16W10]
- 17C55 Finite-dimensional structures of Jordan algebras
- 17C60 Division algebras and Jordan algebras
- 17C65 Jordan structures on Banach spaces and algebras [See also 46H70, 46L70]
- 17C70 Super structures
- 17C90 Applications of Jordan algebras to physics, etc.
- 17C99 None of the above, but in this section

### 17Dxx Other nonassociative rings and algebras

- 17D05 Alternative rings
- 17D10 Mal'tsev rings and algebras
- 17D15 Right alternative rings
- 17D20  $(\gamma, \delta)$ -rings, including  $(1, -1)$ -rings
- 17D25 Lie-admissible algebras
- 17D30 (non-Lie) Hom algebras and topics
- 17D92 Genetic algebras
- 17D99 None of the above, but in this section

### 18-XX Category theory; homological algebra {For commutative rings, see 13Dxx; for associative rings, see 16Exx; for groups, see 20Jxx; for topological groups and related structures, see 57Txx; for algebraic topology, see also 55Nxx, 55Uxx}

- 18-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to category theory
- 18-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to category theory
- 18-02 Research exposition (monographs, survey articles) pertaining to category theory
- 18-03 History of category theory [Consider also classification numbers pertaining to Section 01]
- 18-04 Software, source code, etc. for problems pertaining to category theory
- 18-06 Proceedings, conferences, collections, etc. pertaining to category theory
- 18-08 Computational methods for problems pertaining to category theory
- 18-11 Research data for problems pertaining to category theory

### 18Axx General theory of categories and functors

- 18A05 Definitions and generalizations in theory of categories
- 18A10 Graphs, diagram schemes, precategories
- 18A15 Foundations, relations to logic and deductive systems [See also 03-XX]
- 18A20 Epimorphisms, monomorphisms, special classes of morphisms, null morphisms
- 18A22 Special properties of functors (faithful, full, etc.)
- 18A23 Natural morphisms, dinatural morphisms
- 18A25 Functor categories, comma categories
- 18A30 Limits and colimits (products, sums, directed limits, pushouts, fiber products, equalizers, kernels, ends and coends, etc.)
- 18A32 Factorization systems, substructures, quotient structures, congruences, amalgams
- 18A35 Categories admitting limits (complete categories), functors preserving limits, completions
- 18A40 Adjoint functors (universal constructions, reflective subcategories, Kan extensions, etc.)
- 18A50 Graded categories (general) {For dg categories, see 18G35}
- 18A99 None of the above, but in this section



## 18Bxx Special categories

- 18B05 Categories of sets, characterizations [See also [03-XX](#)]
- 18B10 Categories of spans/cospans, relations, or partial maps
- 18B15 Embedding theorems, universal categories [See also [18E20](#)]
- 18B20 Categories of machines, automata [See also [03D05](#), [68Qxx](#)]
- 18B25 Topoi [See also [03G30](#), [18F10](#)]
- 18B35 Preorders, orders, domains and lattices (viewed as categories) [See also [06-XX](#)]
- 18B40 Groupoids, semigroupoids, semigroups, groups (viewed as categories) [See also [20Axx](#), [20L05](#), [20Mxx](#)]
- 18B50 Extensive, distributive, and adhesive categories
- 18B99 None of the above, but in this section

## 18Cxx Categories and theories

- 18C05 Equational categories [See also [03C05](#), [08C05](#)]
- 18C10 Theories (e.g., algebraic theories), structure, and semantics [See also [03G30](#)]
- 18C15 Monads (= standard construction, monad or triad), algebras for a triple, homology and derived functors for triples [See also [18Gxx](#)] {For functional programming, see also [68N18](#)}
- 18C20 Eilenberg-Moore and Kleisli constructions for monads
- 18C30 Sketches and generalizations
- 18C35 Accessible and locally presentable categories
- 18C40 Structured objects in a category (group objects, etc.)
- 18C50 Categorical semantics of formal languages [See also [68Q55](#), [68Q65](#)]
- 18C99 None of the above, but in this section

## 18Dxx Categorical structures

- 18D15 Closed categories (closed monoidal and Cartesian closed categories, etc.)
- 18D20 Enriched categories (over closed or monoidal categories)
- 18D25 Actions of a monoidal category, tensorial strength {For functional programming, see also [68N18](#)}
- 18D30 Fibered categories
- 18D40 Internal categories and groupoids {For double categories, see [18N10](#); for topological groupoids, see [22A22](#); for Lie groupoids, see [58H05](#)}
- 18D60 Profunctors (= correspondences, distributors, modules)
- 18D65 Proarrow equipments, Yoneda structures, KZ doctrines (lax idempotent monads)
- 18D70 Formal category theory
- 18D99 None of the above, but in this section

## 18Exx Categorical algebra

- 18E05 Preadditive, additive categories
- 18E08 Regular categories, Barr-exact categories
- 18E10 Abelian categories, Grothendieck categories
- 18E13 Protomodular categories, semi-abelian categories, Mal'tsev categories [See also [08B05](#) and [18B10](#)]
- 18E20 Categorical embedding theorems [See also [18B15](#)]
- 18E35 Localization of categories, calculus of fractions {For homotopical aspects, see also [18N45](#), [55P60](#)}
- 18E40 Torsion theories, radicals [See also [13D30](#), [16S90](#)]
- 18E45 Definable subcategories and connections with model theory [See also [13C60](#)]
- 18E50 Categorical Galois theory
- 18E99 None of the above, but in this section

## 18Fxx Categories in geometry and topology

- 18F05 Local categories and functors
- 18F10 Grothendieck topologies and Grothendieck topoi [See also [14F20](#), [18B25](#)]
- 18F15 Abstract manifolds and fiber bundles (category-theoretic aspects) [See also [55Rxx](#), [57Pxx](#)]
- 18F20 Presheaves and sheaves, stacks, descent conditions (category-theoretic aspects) [See also [14F06](#), [14F07](#), [32C35](#), [32L10](#), [54B40](#), [55N30](#)]
- 18F25 Algebraic  $K$ -theory and  $L$ -theory (category-theoretic aspects) [See also [11Exx](#), [11R70](#), [11S70](#), [12-XX](#), [13D15](#), [14Cxx](#), [16E20](#), [19-XX](#), [46L80](#), [57R65](#), [57R67](#)]
- 18F30 Grothendieck groups (category-theoretic aspects) [See also [13D15](#), [16E20](#), [19Axx](#)]
- 18F40 Synthetic differential geometry, tangent categories, differential categories
- 18F50 Goodwillie calculus and functor calculus
- 18F60 Categories of topological spaces and continuous mappings [See also [54-XX](#)]
- 18F70 Frames and locales, pointfree topology, Stone duality [See also [06D22](#), [18B35](#)]
- 18F75 Quantales [See also [06F07](#), [18B35](#)]
- 18F99 None of the above, but in this section

## 18Gxx Homological algebra in category theory, derived categories and functors [See also [13Dxx](#), [16Exx](#), [20Jxx](#), [55Nxx](#), [55Uxx](#), [57Txx](#)]

- 18G05 Projectives and injectives (category-theoretic aspects) [See also [13C10](#), [13C11](#), [16D40](#), [16D50](#)]
- 18G10 Resolutions; derived functors (category-theoretic aspects) [See also [13D02](#), [16E05](#), [18Gxx](#)]
- 18G15 Ext and Tor, generalizations, Künneth formula (category-theoretic aspects) [See also [55U25](#)]
- 18G20 Homological dimension (category-theoretic aspects) [See also [13D05](#), [16E10](#)]
- 18G25 Relative homological algebra, projective classes (category-theoretic aspects)
- 18G31 Simplicial modules and Dold-Kan correspondence
- 18G35 Chain complexes (category-theoretic aspects), dg categories [See also [14F07](#), [18G80](#), [55U15](#)]
- 18G40 Spectral sequences, hypercohomology [See also [55Txx](#)]
- 18G45 2-groups, crossed modules, crossed complexes
- 18G50 Nonabelian homological algebra (category-theoretic aspects)
- 18G65 Stable module categories [See also [20C20](#)]
- 18G70  $A_\infty$ -categories, relations with homological mirror symmetry [See also [14F07](#), [14J33](#), [53D37](#)]
- 18G80 Derived categories, triangulated categories
- 18G85 Graph complexes and graph homology {For relations with deformation quantization, see [53D55](#)}
- 18G90 Other (co)homology theories (category-theoretic aspects) [See also [19D55](#), [46L80](#), [58J20](#), [58J22](#)]
- 18G99 None of the above, but in this section

## 18Mxx Monoidal categories and operads

- 18M05 Monoidal categories, symmetric monoidal categories [See also [19D23](#)]
- 18M10 Traced monoidal categories, compact closed categories, star-autonomous categories
- 18M15 Braided monoidal categories and ribbon categories {For applications to knot theory, see also [57Kxx](#); for applications to quantum groups, see also [16T20](#), [17B37](#), [81R50](#)}
- 18M20 Fusion categories, modular tensor categories, modular functors {For applications to topological quantum field theories, see also [57R56](#); for applications to conformal field theories, see also [81T40](#)}
- 18M25 Tannakian categories {For applications to motives, see also [14C15](#), [19E15](#)}
- 18M30 String diagrams and graphical calculi
- 18M35 Categories of networks and processes, compositionality

- 18M40 Dagger categories, categorical quantum mechanics [See also [81P68](#)]
- 18M45 Categorical aspects of linear logic [See also [03B47](#)]
- 18M50 Bimonoidal, skew-monoidal, duoidal categories
- 18M60 Operads (general)
- 18M65 Non-symmetric operads, multicategories, generalized multicategories
- 18M70 Algebraic operads, cooperads, and Koszul duality
- 18M75 Topological and simplicial operads [See also [18N60](#)]
- 18M80 Species, Hopf monoids, operads in combinatorics
- 18M85 Polycategories/dioperads, properads, PROPs, cyclic operads, modular operads
- 18M90 Globular operads
- 18M99 None of the above, but in this section

## 18Nxx Higher categories and homotopical algebra

- 18N10 2-categories, bicategories, double categories
- 18N15 2-dimensional monad theory [See also [18C15](#)]
- 18N20 Tricategories, weak  $n$ -categories, coherence, semi-strictification
- 18N25 Categorification
- 18N30 Strict omega-categories, computads, polygraphs
- 18N40 Homotopical algebra, Quillen model categories, derivators [See also [55U35](#)]
- 18N45 Categories of fibrations, relations to  $K$ -theory, relations to type theory
- 18N50 Simplicial sets, simplicial objects [See also [55U10](#)]
- 18N55 Localizations (e.g., simplicial localization, Bousfield localization) [See also [18E35](#), [55P60](#)]
- 18N60  $(\infty, 1)$ -categories (quasi-categories, Segal spaces, etc.);  $\infty$ -topoi, stable  $\infty$ -categories [See also [55U35](#), [55U40](#)]
- 18N65  $(\infty, n)$ -categories and  $(\infty, \infty)$ -categories
- 18N70  $\infty$ -operads and higher algebra [See also [18M75](#)]
- 18N99 None of the above, but in this section

## 19-XX $K$ -theory [See also [16E20](#), [18F25](#)]

- 19-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to  $K$ -theory
- 19-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to  $K$ -theory
- 19-02 Research exposition (monographs, survey articles) pertaining to  $K$ -theory
- 19-03 History of  $K$ -theory [Consider also classification numbers pertaining to Section [01](#)]



- 19-04 Software, source code, etc. for problems pertaining to  $K$ -theory
- 19-06 Proceedings, conferences, collections, etc. pertaining to  $K$ -theory
- 19-08 Computational methods for problems pertaining to  $K$ -theory
- 19-11 Research data for problems pertaining to  $K$ -theory

### 19Axx Grothendieck groups and $K_0$ [See also 13D15, 18F30]

- 19A13 Stability for projective modules [See also 13C10]
- 19A15 Efficient generation of modules
- 19A22 Frobenius induction, Burnside and representation rings
- 19A31  $K_0$  of group rings and orders
- 19A49  $K_0$  of other rings
- 19A99 None of the above, but in this section

### 19Bxx Whitehead groups and $K_1$

- 19B10 Stable range conditions
- 19B14 Stability for linear groups
- 19B28  $K_1$  of group rings and orders [See also 57Q10]
- 19B37 Congruence subgroup problems [See also 20H05]
- 19B99 None of the above, but in this section

### 19Cxx Steinberg groups and $K_2$

- 19C09 Central extensions and Schur multipliers
- 19C20 Symbols, presentations and stability of  $K_2$
- 19C30  $K_2$  and the Brauer group
- 19C40 Excision for  $K_2$
- 19C99 None of the above, but in this section

### 19Dxx Higher algebraic $K$ -theory

- 19D06  $Q$ - and plus-constructions
- 19D10 Algebraic  $K$ -theory of spaces
- 19D23 Symmetric monoidal categories [See also 18M05]
- 19D25 Karoubi-Villamayor-Gersten  $K$ -theory
- 19D35 Negative  $K$ -theory, NK and Nil
- 19D45 Higher symbols, Milnor  $K$ -theory
- 19D50 Computations of higher  $K$ -theory of rings [See also 13D15, 16E20]
- 19D55  $K$ -theory and homology; cyclic homology and cohomology [See also 18G90]
- 19D99 None of the above, but in this section

### 19Exx $K$ -theory in geometry

- 19E08  $K$ -theory of schemes [See also 14C35]
- 19E15 Algebraic cycles and motivic cohomology ( $K$ -theoretic aspects) [See also 14C25, 14C35, 14F42]
- 19E20 Relations of  $K$ -theory with cohomology theories [See also 14Fxx]
- 19E99 None of the above, but in this section

### 19Fxx $K$ -theory in number theory [See also 11R70, 11S70]

- 19F05 Generalized class field theory ( $K$ -theoretic aspects) [See also 11G45]
- 19F15 Symbols and arithmetic ( $K$ -theoretic aspects) [See also 11R37]
- 19F27 Étale cohomology, higher regulators, zeta and  $L$ -functions ( $K$ -theoretic aspects) [See also 11G40, 11R42, 11S40, 14F20, 14G10]
- 19F99 None of the above, but in this section

### 19Gxx $K$ -theory of forms [See also 11Exx]

- 19G05 Stability for quadratic modules
- 19G12 Witt groups of rings [See also 11E81]
- 19G24  $L$ -theory of group rings [See also 11E81]
- 19G38 Hermitian  $K$ -theory, relations with  $K$ -theory of rings
- 19G99 None of the above, but in this section

### 19Jxx Obstructions from topology

- 19J05 Finiteness and other obstructions in  $K_0$
- 19J10 Whitehead (and related) torsion
- 19J25 Surgery obstructions ( $K$ -theoretic aspects) [See also 57R67]
- 19J35 Obstructions to group actions ( $K$ -theoretic aspects)
- 19J99 None of the above, but in this section

### 19Kxx $K$ -theory and operator algebras [See mainly 46L80, and also 46M20]

- 19K14  $K_0$  as an ordered group, traces
- 19K33 Ext and  $K$ -homology [See also 55N22]
- 19K35 Kasparov theory ( $KK$ -theory) [See also 58J22]
- 19K56 Index theory [See also 58J20, 58J22]
- 19K99 None of the above, but in this section

## **19Lxx Topological $K$ -theory** [See also [55N15](#), [55R50](#), [55S25](#)]

- 19L10** Riemann-Roch theorems, Chern characters
- 19L20**  $J$ -homomorphism, Adams operations [See also [55Q50](#)]
- 19L41** Connective  $K$ -theory, cobordism [See also [55N22](#)]
- 19L47** Equivariant  $K$ -theory [See also [55N91](#), [55P91](#), [55Q91](#), [55R91](#), [55S91](#)]
- 19L50** Twisted  $K$ -theory; differential  $K$ -theory
- 19L64** Geometric applications of topological  $K$ -theory
- 19L99** None of the above, but in this section

## **19Mxx Miscellaneous applications of $K$ -theory**

- 19M05** Miscellaneous applications of  $K$ -theory
- 19M99** None of the above, but in this section

## **20-XX Group theory and generalizations**

- 20-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to group theory
- 20-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to group theory
- 20-02** Research exposition (monographs, survey articles) pertaining to group theory
- 20-03** History of group theory [Consider also classification numbers pertaining to [Section 01](#)]
- 20-04** Software, source code, etc. for problems pertaining to group theory
- 20-06** Proceedings, conferences, collections, etc. pertaining to group theory
- 20-08** Computational methods for problems pertaining to group theory
- 20-11** Research data for problems pertaining to group theory

### **20Axx Foundations**

- 20A05** Axiomatics and elementary properties of groups
- 20A10** Metamathematical considerations in group theory {For word problems, see [20F10](#)}
- 20A15** Applications of logic to group theory
- 20A99** None of the above, but in this section

### **20Bxx Permutation groups**

- 20B05** General theory for finite permutation groups
- 20B07** General theory for infinite permutation groups
- 20B10** Characterization theorems for permutation groups
- 20B15** Primitive groups

- 20B20** Multiply transitive finite groups
- 20B22** Multiply transitive infinite groups
- 20B25** Finite automorphism groups of algebraic, geometric, or combinatorial structures [See also [05Bxx](#), [12F10](#), [20G40](#), [20H30](#), [51-XX](#)]
- 20B27** Infinite automorphism groups [See also [12F10](#)]
- 20B30** Symmetric groups
- 20B35** Subgroups of symmetric groups
- 20B99** None of the above, but in this section

### **20Cxx Representation theory of groups** {For representation rings and Burnside rings, see also [19A22](#)}

- 20C05** Group rings of finite groups and their modules (group-theoretic aspects) [See also [16S34](#)]
- 20C07** Group rings of infinite groups and their modules (group-theoretic aspects) [See also [16S34](#)]
- 20C08** Hecke algebras and their representations
- 20C10** Integral representations of finite groups
- 20C11**  $p$ -adic representations of finite groups
- 20C12** Integral representations of infinite groups
- 20C15** Ordinary representations and characters
- 20C20** Modular representations and characters
- 20C25** Projective representations and multipliers
- 20C30** Representations of finite symmetric groups
- 20C32** Representations of infinite symmetric groups
- 20C33** Representations of finite groups of Lie type
- 20C34** Representations of sporadic groups
- 20C35** Applications of group representations to physics and other areas of science
- 20C99** None of the above, but in this section

### **20Dxx Abstract finite groups**

- 20D05** Finite simple groups and their classification
- 20D06** Simple groups: alternating groups and groups of Lie type [See also [20Gxx](#)]
- 20D08** Simple groups: sporadic groups
- 20D10** Finite solvable groups, theory of formations, Schunck classes, Fitting classes,  $\pi$ -length, ranks [See also [20F17](#)]
- 20D15** Finite nilpotent groups,  $p$ -groups
- 20D20** Sylow subgroups, Sylow properties,  $\pi$ -groups,  $\pi$ -structure
- 20D25** Special subgroups (Frattini, Fitting, etc.)
- 20D30** Series and lattices of subgroups
- 20D35** Subnormal subgroups of abstract finite groups
- 20D40** Products of subgroups of abstract finite groups
- 20D45** Automorphisms of abstract finite groups
- 20D60** Arithmetic and combinatorial problems involving abstract finite groups
- 20D99** None of the above, but in this section

## 20Exx Structure and classification of infinite or finite groups

- 20E05 Free nonabelian groups
- 20E06 Free products of groups, free products with amalgamation, Higman-Neumann-Neumann extensions, and generalizations
- 20E07 Subgroup theorems; subgroup growth
- 20E08 Groups acting on trees [See also 20F65]
- 20E10 Quasivarieties and varieties of groups
- 20E15 Chains and lattices of subgroups, subnormal subgroups [See also 20F22]
- 20E18 Limits, profinite groups
- 20E22 Extensions, wreath products, and other compositions of groups [See also 20J05]
- 20E25 Local properties of groups
- 20E26 Residual properties and generalizations; residually finite groups
- 20E28 Maximal subgroups
- 20E32 Simple groups [See also 20D05]
- 20E34 General structure theorems for groups
- 20E36 Automorphisms of infinite groups [For automorphisms of finite groups, see 20D45]
- 20E42 Groups with a  $BN$ -pair; buildings [See also 51E24]
- 20E45 Conjugacy classes for groups
- 20E99 None of the above, but in this section

## 20Fxx Special aspects of infinite or finite groups

- 20F05 Generators, relations, and presentations of groups
- 20F06 Cancellation theory of groups; application of van Kampen diagrams [See also 57M05]
- 20F10 Word problems, other decision problems, connections with logic and automata (group-theoretic aspects) [See also 03B25, 03D05, 03D40, 06B25, 08A50, 20M05, 68Q70]
- 20F11 Groups of finite Morley rank [See also 03C45, 03C60]
- 20F12 Commutator calculus
- 20F14 Derived series, central series, and generalizations for groups
- 20F16 Solvable groups, supersolvable groups [See also 20D10]
- 20F17 Formations of groups, Fitting classes [See also 20D10]
- 20F18 Nilpotent groups [See also 20D15]
- 20F19 Generalizations of solvable and nilpotent groups
- 20F22 Other classes of groups defined by subgroup chains
- 20F24 FC-groups and their generalizations
- 20F28 Automorphism groups of groups [See also 20E36]

- 20F29 Representations of groups as automorphism groups of algebraic systems
- 20F34 Fundamental groups and their automorphisms (group-theoretic aspects) [See also 57M05, 57Sxx]
- 20F36 Braid groups; Artin groups
- 20F38 Other groups related to topology or analysis
- 20F40 Associated Lie structures for groups
- 20F45 Engel conditions
- 20F50 Periodic groups; locally finite groups
- 20F55 Reflection and Coxeter groups (group-theoretic aspects) [See also 22E40, 51F15]
- 20F60 Ordered groups (group-theoretic aspects) [See mainly 06F15]
- 20F65 Geometric group theory [See also 05C25, 20E08, 57Mxx]
- 20F67 Hyperbolic groups and nonpositively curved groups
- 20F69 Asymptotic properties of groups
- 20F70 Algebraic geometry over groups; equations over groups
- 20F99 None of the above, but in this section

## 20Gxx Linear algebraic groups and related topics {For arithmetic theory, see 11E57, 11H56; for geometric theory, see 14Lxx, 22Exx; for other methods in representation theory, see 15A30, 22E45, 22E46, 22E47, 22E50, 22E55}

- 20G05 Representation theory for linear algebraic groups
- 20G07 Structure theory for linear algebraic groups
- 20G10 Cohomology theory for linear algebraic groups
- 20G15 Linear algebraic groups over arbitrary fields
- 20G20 Linear algebraic groups over the reals, the complexes, the quaternions
- 20G25 Linear algebraic groups over local fields and their integers
- 20G30 Linear algebraic groups over global fields and their integers
- 20G35 Linear algebraic groups over adèles and other rings and schemes
- 20G40 Linear algebraic groups over finite fields
- 20G41 Exceptional groups
- 20G42 Quantum groups (quantized function algebras) and their representations [See also 16T20, 17B37, 81R50]
- 20G43 Schur and  $q$ -Schur algebras
- 20G44 Kac-Moody groups
- 20G45 Applications of linear algebraic groups to the sciences
- 20G99 None of the above, but in this section

## 20Hxx Other groups of matrices [See also 15A30]

- 20H05 Unimodular groups, congruence subgroups (group-theoretic aspects) [See also 11F06, 19B37, 22E40, 51F20]
- 20H10 Fuchsian groups and their generalizations (group-theoretic aspects) [See also 11F06, 22E40, 30F35, 32Nxx]
- 20H15 Other geometric groups, including crystallographic groups [See also 51-XX, especially 51F15, and 82D25]
- 20H20 Other matrix groups over fields
- 20H25 Other matrix groups over rings
- 20H30 Other matrix groups over finite fields
- 20H99 None of the above, but in this section

## 20Jxx Connections of group theory with homological algebra and category theory

- 20J05 Homological methods in group theory
- 20J06 Cohomology of groups
- 20J15 Category of groups
- 20J99 None of the above, but in this section

## 20Kxx Abelian groups

- 20K01 Finite abelian groups {For sumsets, see 11B13, 11P70}
- 20K10 Torsion groups, primary groups and generalized primary groups
- 20K15 Torsion-free groups, finite rank
- 20K20 Torsion-free groups, infinite rank
- 20K21 Mixed groups
- 20K25 Direct sums, direct products, etc. for abelian groups
- 20K27 Subgroups of abelian groups
- 20K30 Automorphisms, homomorphisms, endomorphisms, etc. for abelian groups
- 20K35 Extensions of abelian groups
- 20K40 Homological and categorical methods for abelian groups
- 20K45 Topological methods for abelian groups [See also 22A05, 22B05]
- 20K99 None of the above, but in this section

## 20Lxx Groupoids (i.e. small categories in which all morphisms are isomorphisms) {For sets with a single binary operation, see 20N02; for topological groupoids, see 22A22, 58H05}

- 20L05 Groupoids (i.e. small categories in which all morphisms are isomorphisms) {For sets with a single binary operation, see 20N02; for topological groupoids, see 22A22, 58H05}

- 20L99 None of the above, but in this section

## 20Mxx Semigroups

- 20M05 Free semigroups, generators and relations, word problems [See also 03D40, 08A50, 20F10]
- 20M07 Varieties and pseudovarieties of semigroups
- 20M10 General structure theory for semigroups
- 20M11 Radical theory for semigroups
- 20M12 Ideal theory for semigroups
- 20M13 Arithmetic theory of semigroups
- 20M14 Commutative semigroups
- 20M15 Mappings of semigroups
- 20M17 Regular semigroups
- 20M18 Inverse semigroups
- 20M19 Orthodox semigroups
- 20M20 Semigroups of transformations, relations, partitions, etc. [See also 47D03, 47H20, 54H15]
- 20M25 Semigroup rings, multiplicative semigroups of rings [See also 16S36, 16Y60]
- 20M30 Representation of semigroups; actions of semigroups on sets
- 20M32 Algebraic monoids
- 20M35 Semigroups in automata theory, linguistics, etc. [See also 03D05, 68Q70, 68T50]
- 20M50 Connections of semigroups with homological algebra and category theory
- 20M75 Generalizations of semigroups
- 20M99 None of the above, but in this section

## 20Nxx Other generalizations of groups

- 20N02 Sets with a single binary operation (groupoids) {For groupoids in connection with category theory, see 20L05; for topological groupoids, see 22A22, 58H05}
- 20N05 Loops, quasigroups [See also 05Bxx]
- 20N10 Ternary systems (heaps, semiheaps, heapoids, etc.)
- 20N15  $n$ -ary systems ( $n \geq 3$ )
- 20N20 Hypergroups
- 20N25 Fuzzy groups [See also 03E72]
- 20N99 None of the above, but in this section

## 20Pxx Probabilistic methods in group theory [See also 60Bxx]

- 20P05 Probabilistic methods in group theory [See also 60Bxx]
- 20P99 None of the above, but in this section

## 22-XX Topological groups, Lie groups {For transformation groups, see 54H15, 57Sxx, 58-XX; for abstract harmonic analysis, see 43-XX}

- 22-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to topological groups
- 22-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to topological groups
- 22-02 Research exposition (monographs, survey articles) pertaining to topological groups
- 22-03 History of topological groups [Consider also classification numbers pertaining to Section 01]
- 22-04 Software, source code, etc. for problems pertaining to topological groups
- 22-06 Proceedings, conferences, collections, etc. pertaining to topological groups
- 22-08 Computational methods for problems pertaining to topological groups
- 22-11 Research data for problems pertaining to topological groups

## 22Axx Topological and differentiable algebraic systems {For topological rings and fields, see 12Jxx, 13Jxx, 16W80}

- 22A05 Structure of general topological groups
- 22A10 Analysis on general topological groups
- 22A15 Structure of topological semigroups
- 22A20 Analysis on topological semigroups
- 22A22 Topological groupoids (including differentiable and Lie groupoids) [See also 58H05]
- 22A25 Representations of general topological groups and semigroups
- 22A26 Topological semilattices, lattices and applications [See also 06B30, 06B35, 06F30]
- 22A30 Other topological algebraic systems and their representations
- 22A99 None of the above, but in this section

## 22Bxx Locally compact abelian groups (LCA groups)

- 22B05 General properties and structure of LCA groups
- 22B10 Structure of group algebras of LCA groups
- 22B99 None of the above, but in this section

## 22Cxx Compact groups

- 22C05 Compact groups
- 22C99 None of the above, but in this section

## 22Dxx Locally compact groups and their algebras

- 22D05 General properties and structure of locally compact groups
- 22D10 Unitary representations of locally compact groups
- 22D12 Other representations of locally compact groups
- 22D15 Group algebras of locally compact groups
- 22D20 Representations of group algebras
- 22D25  $C^*$ -algebras and  $W^*$ -algebras in relation to group representations [See also 46Lxx]
- 22D30 Induced representations for locally compact groups
- 22D35 Duality theorems for locally compact groups
- 22D40 Ergodic theory on groups [See also 28Dxx]
- 22D45 Automorphism groups of locally compact groups
- 22D50 Rigidity in locally compact groups
- 22D55 Kazhdan's property (T), the Haagerup property, and generalizations
- 22D99 None of the above, but in this section

## 22Exx Lie groups {For the topology of Lie groups and homogeneous spaces, see 57Sxx, 57Txx; for analysis thereon, see 43A80, 43A85, 43A90}

- 22E05 Local Lie groups [See also 34-XX, 35-XX, 58H05]
- 22E10 General properties and structure of complex Lie groups [See also 32M05]
- 22E15 General properties and structure of real Lie groups
- 22E20 General properties and structure of other Lie groups
- 22E25 Nilpotent and solvable Lie groups
- 22E27 Representations of nilpotent and solvable Lie groups (special orbital integrals, non-type I representations, etc.)
- 22E30 Analysis on real and complex Lie groups [See also 33C80, 43-XX]
- 22E35 Analysis on  $p$ -adic Lie groups
- 22E40 Discrete subgroups of Lie groups [See also 20Hxx, 32Nxx]
- 22E41 Continuous cohomology of Lie groups [See also 57R32, 57Txx, 58H10]
- 22E43 Structure and representation of the Lorentz group
- 22E45 Representations of Lie and linear algebraic groups over real fields: analytic methods {For the purely algebraic theory, see 20G05}
- 22E46 Semisimple Lie groups and their representations
- 22E47 Representations of Lie and real algebraic groups: algebraic methods (Verma modules, etc.) [See also 17B10]



- 22E50** Representations of Lie and linear algebraic groups over local fields [See also [20G05](#)]
- 22E55** Representations of Lie and linear algebraic groups over global fields and adèle rings [See also [20G05](#)]
- 22E57** Geometric Langlands program: representation-theoretic aspects [See also [14D24](#)]
- 22E60** Lie algebras of Lie groups {For the algebraic theory of Lie algebras, see [17Bxx](#)}
- 22E65** Infinite-dimensional Lie groups and their Lie algebras: general properties [See also [17B65](#), [58B25](#), [58D05](#), [58H05](#)]
- 22E66** Analysis on and representations of infinite-dimensional Lie groups
- 22E67** Loop groups and related constructions, group-theoretic treatment [See also [58D05](#)]
- 22E70** Applications of Lie groups to the sciences; explicit representations [See also [81R05](#), [81R10](#)]
- 22E99** None of the above, but in this section

## 22Fxx Noncompact transformation groups

- 22F05** General theory of group and pseudogroup actions {For topological properties of spaces with an action, see [57S20](#)}
- 22F10** Measurable group actions [See also [22D40](#), [28Dxx](#), [37Axx](#)]
- 22F30** Homogeneous spaces {For general actions on manifolds or preserving geometrical structures, see [57M60](#), [57Sxx](#); for discrete subgroups of Lie groups, see especially [22E40](#)}
- 22F50** Groups as automorphisms of other structures
- 22F99** None of the above, but in this section

## 26-XX Real functions [See also [54C30](#)]

- 26-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to real functions
- 26-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to real functions
- 26-02** Research exposition (monographs, survey articles) pertaining to real functions
- 26-03** History of real functions [Consider also classification numbers pertaining to Section [01](#)]
- 26-04** Software, source code, etc. for problems pertaining to real functions
- 26-06** Proceedings, conferences, collections, etc. pertaining to real functions
- 26-08** Computational methods for problems pertaining to real functions
- 26-11** Research data for problems pertaining to real functions

## 26Axx Functions of one variable

- 26A03** Foundations: limits and generalizations, elementary topology of the line
- 26A06** One-variable calculus
- 26A09** Elementary functions
- 26A12** Rate of growth of functions, orders of infinity, slowly varying functions [See also [26A48](#)]
- 26A15** Continuity and related questions (modulus of continuity, semicontinuity, discontinuities, etc.) for real functions in one variable {For properties determined by Fourier coefficients, see [42A16](#); for those determined by approximation properties, see [41A25](#), [41A27](#)}
- 26A16** Lipschitz (Hölder) classes
- 26A18** Iteration of real functions in one variable [See also [37Bxx](#), [37Cxx](#), [37Exx](#), [39B12](#), [47H10](#), [54H25](#)]
- 26A21** Classification of real functions; Baire classification of sets and functions [See also [03E15](#), [28A05](#), [54C50](#), [54H05](#)]
- 26A24** Differentiation (real functions of one variable): general theory, generalized derivatives, mean value theorems [See also [28A15](#)]
- 26A27** Nondifferentiability (nondifferentiable functions, points of nondifferentiability), discontinuous derivatives
- 26A30** Singular functions, Cantor functions, functions with other special properties
- 26A33** Fractional derivatives and integrals
- 26A36** Antidifferentiation
- 26A39** Denjoy and Perron integrals, other special integrals
- 26A42** Integrals of Riemann, Stieltjes and Lebesgue type [See also [28-XX](#)]
- 26A45** Functions of bounded variation, generalizations
- 26A46** Absolutely continuous real functions in one variable
- 26A48** Monotonic functions, generalizations
- 26A51** Convexity of real functions in one variable, generalizations
- 26A99** None of the above, but in this section

## 26Bxx Functions of several variables

- 26B05** Continuity and differentiation questions
- 26B10** Implicit function theorems, Jacobians, transformations with several variables
- 26B12** Calculus of vector functions
- 26B15** Integration of real functions of several variables: length, area, volume [See also [28A75](#), [51M25](#)]
- 26B20** Integral formulas of real functions of several variables (Stokes, Gauss, Green, etc.)
- 26B25** Convexity of real functions of several variables, generalizations

- 26B30** Absolutely continuous real functions of several variables, functions of bounded variation
- 26B35** Special properties of functions of several variables, Hölder conditions, etc.
- 26B40** Representation and superposition of functions
- 26B99** None of the above, but in this section

### **26Cxx Polynomials, rational functions in real analysis**

- 26C05** Real polynomials: analytic properties, etc. [See also [12Dxx](#), [12Exx](#)]
- 26C10** Real polynomials: location of zeros [See also [12D10](#), [30C15](#), [65H05](#)]
- 26C15** Real rational functions [See also [14Pxx](#)]
- 26C99** None of the above, but in this section

### **26Dxx Inequalities in real analysis {For maximal function inequalities, see [42B25](#); for functional inequalities, see [39B72](#); for probabilistic inequalities, see [60E15](#)}**

- 26D05** Inequalities for trigonometric functions and polynomials
- 26D07** Inequalities involving other types of functions
- 26D10** Inequalities involving derivatives and differential and integral operators
- 26D15** Inequalities for sums, series and integrals
- 26D20** Other analytical inequalities
- 26D99** None of the above, but in this section

### **26Exx Miscellaneous topics in real functions [See also [58Cxx](#)]**

- 26E05** Real-analytic functions [See also [32B05](#), [32C05](#)]
- 26E10**  $C^\infty$ -functions, quasi-analytic functions [See also [58C25](#)]
- 26E15** Calculus of functions on infinite-dimensional spaces [See also [46G05](#), [58Cxx](#)]
- 26E20** Calculus of functions taking values in infinite-dimensional spaces [See also [46E40](#), [46G10](#), [58Cxx](#)]
- 26E25** Set-valued functions [See also [28B20](#), [49J53](#), [54C60](#)] {For nonsmooth analysis, see [49J52](#), [58Cxx](#), [90Cxx](#)}
- 26E30** Non-Archimedean analysis [See also [12J25](#)]
- 26E35** Nonstandard analysis [See also [03H05](#), [28E05](#), [54J05](#)]
- 26E40** Constructive real analysis [See also [03F60](#)]
- 26E50** Fuzzy real analysis [See also [03E72](#), [28E10](#)]
- 26E60** Means [See also [47A64](#)]
- 26E70** Real analysis on time scales or measure chains {For dynamic equations on time scales or measure chains, see [34N05](#)}
- 26E99** None of the above, but in this section

## **28-XX Measure and integration {For analysis on manifolds, see [58-XX](#)}**

- 28-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to measure and integration
- 28-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to measure and integration
- 28-02** Research exposition (monographs, survey articles) pertaining to measure and integration
- 28-03** History of measure and integration [Consider also classification numbers pertaining to Section [01](#)]
- 28-04** Software, source code, etc. for problems pertaining to measure and integration
- 28-06** Proceedings, conferences, collections, etc. pertaining to measure and integration
- 28-08** Computational methods for problems pertaining to measure and integration
- 28-11** Research data for problems pertaining to measure and integration

### **28Axx Classical measure theory**

- 28A05** Classes of sets (Borel fields,  $\sigma$ -rings, etc.), measurable sets, Suslin sets, analytic sets [See also [03E15](#), [26A21](#), [54H05](#)]
- 28A10** Real- or complex-valued set functions
- 28A12** Contents, measures, outer measures, capacities
- 28A15** Abstract differentiation theory, differentiation of set functions [See also [26A24](#)]
- 28A20** Measurable and nonmeasurable functions, sequences of measurable functions, modes of convergence
- 28A25** Integration with respect to measures and other set functions
- 28A33** Spaces of measures, convergence of measures [See also [46E27](#), [60Bxx](#)]
- 28A35** Measures and integrals in product spaces
- 28A50** Integration and disintegration of measures
- 28A51** Lifting theory [See also [46G15](#)]
- 28A60** Measures on Boolean rings, measure algebras [See also [54H10](#)]
- 28A75** Length, area, volume, other geometric measure theory [See also [26B15](#), [49Q15](#)]
- 28A78** Hausdorff and packing measures
- 28A80** Fractals [See also [37Fxx](#)]
- 28A99** None of the above, but in this section



## **28Bxx Set functions, measures and integrals with values in abstract spaces**

- 28B05** Vector-valued set functions, measures and integrals [See also [46G10](#)]
- 28B10** Group- or semigroup-valued set functions, measures and integrals
- 28B15** Set functions, measures and integrals with values in ordered spaces
- 28B20** Set-valued set functions and measures; integration of set-valued functions; measurable selections [See also [26E25](#), [54C60](#), [54C65](#), [91B14](#)]
- 28B99** None of the above, but in this section

## **28Cxx Set functions and measures on spaces with additional structure [See also [46G12](#), [58C35](#), [58D20](#)]**

- 28C05** Integration theory via linear functionals (Radon measures, Daniell integrals, etc.), representing set functions and measures
- 28C10** Set functions and measures on topological groups or semigroups, Haar measures, invariant measures [See also [22Axx](#), [43A05](#)]
- 28C15** Set functions and measures on topological spaces (regularity of measures, etc.)
- 28C20** Set functions and measures and integrals in infinite-dimensional spaces (Wiener measure, Gaussian measure, etc.) [See also [46G12](#), [58C35](#), [58D20](#), [60B11](#)]
- 28C99** None of the above, but in this section

## **28Dxx Measure-theoretic ergodic theory [See also [11K50](#), [11K55](#), [22D40](#), [37Axx](#), [47A35](#), [60Fxx](#), [60G10](#)]**

- 28D05** Measure-preserving transformations {For measure-preserving transformations and dynamical systems, see [37A05](#)}
- 28D10** One-parameter continuous families of measure-preserving transformations {For dynamical systems aspect, see [37A10](#)}
- 28D15** General groups of measure-preserving transformations {For dynamical systems aspects, see [37A15](#)}
- 28D20** Entropy and other invariants
- 28D99** None of the above, but in this section

## **28Exx Miscellaneous topics in measure theory**

- 28E05** Nonstandard measure theory [See also [03H05](#), [26E35](#)]
- 28E10** Fuzzy measure theory [See also [03E72](#), [26E50](#), [94D05](#)]
- 28E15** Other connections with logic and set theory
- 28E99** None of the above, but in this section

## **30-XX Functions of a complex variable**

- 30-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to functions of a complex variable
- 30-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to functions of a complex variable
- 30-02** Research exposition (monographs, survey articles) pertaining to functions of a complex variable
- 30-03** History of functions of a complex variable [Consider also classification numbers pertaining to Section [01](#)]
- 30-04** Software, source code, etc. for problems pertaining to functions of a complex variable
- 30-06** Proceedings, conferences, collections, etc. pertaining to functions of a complex variable
- 30-08** Computational methods for problems pertaining to functions of a complex variable [See also [65Exx](#)]
- 30-11** Research data for problems pertaining to functions of a complex variable

## **30Axx General properties of functions of one complex variable**

- 30A05** Monogenic and polygenic functions of one complex variable
- 30A10** Inequalities in the complex plane
- 30A99** None of the above, but in this section

## **30Bxx Series expansions of functions of one complex variable**

- 30B10** Power series (including lacunary series) in one complex variable
- 30B20** Random power series in one complex variable
- 30B30** Boundary behavior of power series in one complex variable; over-convergence
- 30B40** Analytic continuation of functions of one complex variable
- 30B50** Dirichlet series, exponential series and other series in one complex variable [See also [11M41](#), [42-XX](#)]
- 30B60** Completeness problems, closure of a system of functions of one complex variable
- 30B70** Continued fractions; complex-analytic aspects [See also [11A55](#), [40A15](#)]
- 30B99** None of the above, but in this section

## 30Cxx Geometric function theory

- 30C10 Polynomials and rational functions of one complex variable
- 30C15 Zeros of polynomials, rational functions, and other analytic functions of one complex variable (e.g., zeros of functions with bounded Dirichlet integral) {For algebraic theory, see [12D10](#); for real methods, see [26C10](#)}
- 30C20 Conformal mappings of special domains
- 30C25 Covering theorems in conformal mapping theory
- 30C30 Schwarz-Christoffel-type mappings [See also [65E10](#)]
- 30C35 General theory of conformal mappings
- 30C40 Kernel functions in one complex variable and applications
- 30C45 Special classes of univalent and multivalent functions of one complex variable (starlike, convex, bounded rotation, etc.)
- 30C50 Coefficient problems for univalent and multivalent functions of one complex variable
- 30C55 General theory of univalent and multivalent functions of one complex variable
- 30C62 Quasiconformal mappings in the complex plane
- 30C65 Quasiconformal mappings in  $\mathbb{R}^n$ , other generalizations
- 30C70 Extremal problems for conformal and quasiconformal mappings, variational methods
- 30C75 Extremal problems for conformal and quasiconformal mappings, other methods
- 30C80 Maximum principle, Schwarz's lemma, Lindelöf principle, analogues and generalizations; subordination
- 30C85 Capacity and harmonic measure in the complex plane [See also [31A15](#)]
- 30C99 None of the above, but in this section

## 30Dxx Entire and meromorphic functions of one complex variable, and related topics

- 30D05 Functional equations in the complex plane, iteration and composition of analytic functions of one complex variable [See also [34Mxx](#), [37Fxx](#), [39-XX](#)]
- 30D10 Representations of entire functions of one complex variable by series and integrals
- 30D15 Special classes of entire functions of one complex variable and growth estimates
- 30D20 Entire functions of one complex variable, general theory
- 30D30 Meromorphic functions of one complex variable, general theory
- 30D35 Value distribution of meromorphic functions of one complex variable, Nevanlinna theory
- 30D40 Cluster sets, prime ends, boundary behavior

- 30D45 Normal functions of one complex variable, normal families
- 30D60 Quasi-analytic and other classes of functions of one complex variable
- 30D99 None of the above, but in this section

## 30Exx Miscellaneous topics of analysis in the complex plane

- 30E05 Moment problems and interpolation problems in the complex plane
- 30E10 Approximation in the complex plane
- 30E15 Asymptotic representations in the complex plane
- 30E20 Integration, integrals of Cauchy type, integral representations of analytic functions in the complex plane [See also [45Exx](#)]
- 30E25 Boundary value problems in the complex plane [See also [45Exx](#)]
- 30E99 None of the above, but in this section

## 30Fxx Riemann surfaces

- 30F10 Compact Riemann surfaces and uniformization [See also [14H15](#), [32G15](#)]
- 30F15 Harmonic functions on Riemann surfaces
- 30F20 Classification theory of Riemann surfaces
- 30F25 Ideal boundary theory for Riemann surfaces
- 30F30 Differentials on Riemann surfaces
- 30F35 Fuchsian groups and automorphic functions (aspects of compact Riemann surfaces and uniformization) [See also [11Fxx](#), [20H10](#), [22E40](#), [32Gxx](#), [32Nxx](#)]
- 30F40 Kleinian groups (aspects of compact Riemann surfaces and uniformization) [See also [20H10](#)]
- 30F45 Conformal metrics (hyperbolic, Poincaré, distance functions)
- 30F50 Klein surfaces
- 30F60 Teichmüller theory [See also [32G15](#)]
- 30F99 None of the above, but in this section

## 30Gxx Generalized function theory

- 30G06 Non-Archimedean function theory [See also [12J25](#)]; nonstandard function theory [See also [03H05](#)]
- 30G12 Finely holomorphic functions and topological function theory
- 30G20 Generalizations of Bers and Vekua type (pseudoanalytic,  $p$ -analytic, etc.)
- 30G25 Discrete analytic functions
- 30G30 Other generalizations of analytic functions (including abstract-valued functions)
- 30G35 Functions of hypercomplex variables and generalized variables
- 30G99 None of the above, but in this section

## 30Hxx Spaces and algebras of analytic functions of one complex variable

- 30H05 Spaces of bounded analytic functions of one complex variable
- 30H10 Hardy spaces [See also 42B30, 46E30]
- 30H15 Nevanlinna spaces and Smirnov spaces
- 30H20 Bergman spaces and Fock spaces [See also 46E30, 46E35]
- 30H25 Besov spaces and  $Q_p$ -spaces
- 30H30 Bloch spaces
- 30H35 BMO-spaces
- 30H40 Zygmund spaces
- 30H45 de Branges-Rovnyak spaces
- 30H50 Algebras of analytic functions of one complex variable
- 30H80 Corona theorems
- 30H99 None of the above, but in this section

## 30Jxx Function theory on the disc

- 30J05 Inner functions of one complex variable
- 30J10 Blaschke products
- 30J15 Singular inner functions of one complex variable
- 30J99 None of the above, but in this section

## 30Kxx Universal holomorphic functions of one complex variable

- 30K05 Universal Taylor series in one complex variable
- 30K10 Universal Dirichlet series in one complex variable
- 30K15 Universal functions of one complex variable
- 30K20 Compositional universality
- 30K99 None of the above, but in this section

## 30Lxx Analysis on metric spaces

- 30L05 Geometric embeddings of metric spaces
- 30L10 Quasiconformal mappings in metric spaces
- 30L15 Inequalities in metric spaces
- 30L99 None of the above, but in this section

## 31-XX Potential theory {For probabilistic potential theory, see 60J45}

- 31-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to potential theory
- 31-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to potential theory

- 31-02 Research exposition (monographs, survey articles) pertaining to potential theory
- 31-03 History of potential theory [Consider also classification numbers pertaining to Section 01]
- 31-04 Software, source code, etc. for problems pertaining to potential theory
- 31-06 Proceedings, conferences, collections, etc. pertaining to potential theory
- 31-08 Computational methods for problems pertaining to potential theory [See also 65Exx]
- 31-11 Research data for problems pertaining to potential theory

## 31Axx Two-dimensional potential theory

- 31A05 Harmonic, subharmonic, superharmonic functions in two dimensions
- 31A10 Integral representations, integral operators, integral equations methods in two dimensions
- 31A15 Potentials and capacity, harmonic measure, extremal length and related notions in two dimensions [See also 30C85]
- 31A20 Boundary behavior (theorems of Fatou type, etc.) of harmonic functions in two dimensions
- 31A25 Boundary value and inverse problems for harmonic functions in two dimensions
- 31A30 Biharmonic, polyharmonic functions and equations, Poisson's equation in two dimensions
- 31A35 Connections of harmonic functions with differential equations in two dimensions
- 31A99 None of the above, but in this section

## 31Bxx Higher-dimensional potential theory

- 31B05 Harmonic, subharmonic, superharmonic functions in higher dimensions
- 31B10 Integral representations, integral operators, integral equations methods in higher dimensions
- 31B15 Potentials and capacities, extremal length and related notions in higher dimensions
- 31B20 Boundary value and inverse problems for harmonic functions in higher dimensions
- 31B25 Boundary behavior of harmonic functions in higher dimensions
- 31B30 Biharmonic and polyharmonic equations and functions in higher dimensions
- 31B35 Connections of harmonic functions with differential equations in higher dimensions
- 31B99 None of the above, but in this section

## 31Cxx Generalizations of potential theory

- 31C05 Harmonic, subharmonic, superharmonic functions on other spaces
- 31C10 Pluriharmonic and plurisubharmonic functions [See also 32U05]
- 31C12 Potential theory on Riemannian manifolds and other spaces [See also 53C20] {For Hodge theory, see 58A14}
- 31C15 Potentials and capacities on other spaces
- 31C20 Discrete potential theory
- 31C25 Dirichlet forms
- 31C35 Martin boundary theory [See also 60J50]
- 31C40 Fine potential theory; fine properties of sets and functions
- 31C45 Other generalizations (nonlinear potential theory, etc.)
- 31C99 None of the above, but in this section

## 31Dxx Axiomatic potential theory

- 31D05 Axiomatic potential theory
- 31D99 None of the above, but in this section

## 31Exx Potential theory on fractals and metric spaces

- 31E05 Potential theory on fractals and metric spaces
- 31E99 None of the above, but in this section

## 32-XX Several complex variables and analytic spaces {For infinite-dimensional holomorphy, see also 46G20, 58B12}

- 32-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to several complex variables and analytic spaces
- 32-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to several complex variables and analytic spaces
- 32-02 Research exposition (monographs, survey articles) pertaining to several complex variables and analytic spaces
- 32-03 History of several complex variables and analytic spaces [Consider also classification numbers pertaining to Section 01]
- 32-04 Software, source code, etc. for problems pertaining to several complex variables and analytic spaces
- 32-06 Proceedings, conferences, collections, etc. pertaining to several complex variables and analytic spaces
- 32-08 Computational methods for problems pertaining to several complex variables and analytic spaces [See also 65Exx]

- 32-11 Research data for problems pertaining to several complex variables and analytic spaces

## 32Axx Holomorphic functions of several complex variables

- 32A05 Power series, series of functions of several complex variables
- 32A08 Polynomials and rational functions of several complex variables
- 32A10 Holomorphic functions of several complex variables
- 32A12 Multifunctions of several complex variables
- 32A15 Entire functions of several complex variables
- 32A17 Special families of functions of several complex variables
- 32A18 Bloch functions, normal functions of several complex variables
- 32A19 Normal families of holomorphic functions, mappings of several complex variables, and related topics (taut manifolds etc.)
- 32A20 Meromorphic functions of several complex variables
- 32A22 Nevanlinna theory; growth estimates; other inequalities of several complex variables {For geometric theory, see 32H25, 32H30}
- 32A25 Integral representations; canonical kernels (Szegő, Bergman, etc.)
- 32A26 Integral representations, constructed kernels (e.g., Cauchy, Fantappiè-type kernels)
- 32A27 Residues for several complex variables [See also 32C30]
- 32A30 Other generalizations of function theory of one complex variable (should also be assigned at least one classification number from Section 30) {For functions of several hypercomplex variables, see 30G35}
- 32A35  $H^p$ -spaces, Nevanlinna spaces of functions in several complex variables [See also 32M15, 42B30, 43A85, 46J15]
- 32A36 Bergman spaces of functions in several complex variables
- 32A37 Other spaces of holomorphic functions of several complex variables (e.g., bounded mean oscillation (BMOA), vanishing mean oscillation (VMOA)) [See also 46Exx]
- 32A38 Algebras of holomorphic functions of several complex variables [See also 46J10, 46J15]
- 32A40 Boundary behavior of holomorphic functions of several complex variables
- 32A45 Hyperfunctions [See also 46F15]
- 32A50 Harmonic analysis of several complex variables [See mainly 43-XX]
- 32A55 Singular integrals of functions in several complex variables

- 32A60** Zero sets of holomorphic functions of several complex variables
- 32A65** Banach algebra techniques applied to functions of several complex variables [See also [46Jxx](#)]
- 32A70** Functional analysis techniques applied to functions of several complex variables [See also [46Exx](#)]
- 32A99** None of the above, but in this section

### **32Bxx Local analytic geometry [See also [13-XX](#), [14-XX](#)]**

- 32B05** Analytic algebras and generalizations, preparation theorems
- 32B10** Germs of analytic sets, local parametrization
- 32B15** Analytic subsets of affine space
- 32B20** Semi-analytic sets, subanalytic sets, and generalizations [See also [14P15](#)]
- 32B25** Triangulation and topological properties of semi-analytic and subanalytic sets, and related questions
- 32B99** None of the above, but in this section

### **32Cxx Analytic spaces**

- 32C05** Real-analytic manifolds, real-analytic spaces [See also [14Pxx](#), [58A07](#)]
- 32C07** Real-analytic sets, complex Nash functions [See also [14P15](#), [14P20](#)]
- 32C09** Embedding of real-analytic manifolds
- 32C11** Complex supergeometry [See also [14A22](#), [14M30](#), [58A50](#)]
- 32C15** Complex spaces
- 32C18** Topology of analytic spaces
- 32C20** Normal analytic spaces
- 32C22** Embedding of analytic spaces
- 32C25** Analytic subsets and submanifolds
- 32C30** Integration on analytic sets and spaces, currents [See also [32A25](#), [32A27](#)]
- 32C35** Analytic sheaves and cohomology groups [See also [14Fxx](#), [18F20](#), [55N30](#)]
- 32C36** Local cohomology of analytic spaces
- 32C37** Duality theorems for analytic spaces
- 32C38** Sheaves of differential operators and their modules,  $D$ -modules [See also [14F10](#), [16S32](#), [35A27](#), [58J15](#)]
- 32C55** The Levi problem in complex spaces; generalizations
- 32C81** Applications of analytic spaces to physics and other areas of science
- 32C99** None of the above, but in this section

### **32Dxx Analytic continuation**

- 32D05** Domains of holomorphy
- 32D10** Envelopes of holomorphy
- 32D15** Continuation of analytic objects in several complex variables
- 32D20** Removable singularities in several complex variables
- 32D26** Riemann domains
- 32D99** None of the above, but in this section

### **32Exx Holomorphic convexity**

- 32E05** Holomorphically convex complex spaces, reduction theory
- 32E10** Stein spaces, Stein manifolds
- 32E20** Polynomial convexity, rational convexity, meromorphic convexity in several complex variables
- 32E30** Holomorphic, polynomial and rational approximation, and interpolation in several complex variables; Runge pairs
- 32E35** Global boundary behavior of holomorphic functions of several complex variables
- 32E40** The Levi problem
- 32E99** None of the above, but in this section

### **32Fxx Geometric convexity in several complex variables**

- 32F10**  $q$ -convexity,  $q$ -concavity
- 32F17** Other notions of convexity in relation to several complex variables
- 32F18** Finite-type conditions for the boundary of a domain
- 32F27** Topological consequences of geometric convexity
- 32F32** Analytical consequences of geometric convexity (vanishing theorems, etc.)
- 32F45** Invariant metrics and pseudodistances in several complex variables
- 32F99** None of the above, but in this section

### **32Gxx Deformations of analytic structures**

- 32G05** Deformations of complex structures [See also [13D10](#), [16S80](#), [58H10](#), [58H15](#)]
- 32G07** Deformations of special (e.g., CR) structures
- 32G08** Deformations of fiber bundles
- 32G10** Deformations of submanifolds and subspaces
- 32G13** Complex-analytic moduli problems {For algebraic moduli problems, see [14D20](#), [14D22](#), [14H10](#), [14J10](#)} [See also [14H15](#), [14J15](#)]
- 32G15** Moduli of Riemann surfaces, Teichmüller theory (complex-analytic aspects in several variables) [See also [14H15](#), [30Fxx](#)]



- 32G20** Period matrices, variation of Hodge structure; degenerations [See also [14D05](#), [14D07](#), [14K30](#)]
- 32G34** Moduli and deformations for ordinary differential equations (e.g., Knizhnik-Zamolodchikov equation) [See also [34Mxx](#)]
- 32G81** Applications of deformations of analytic structures to the sciences
- 32G99** None of the above, but in this section

## **32Hxx Holomorphic mappings and correspondences**

- 32H02** Holomorphic mappings, (holomorphic) embeddings and related questions in several complex variables
- 32H04** Meromorphic mappings in several complex variables
- 32H12** Boundary uniqueness of mappings in several complex variables
- 32H25** Picard-type theorems and generalizations for several complex variables {For function-theoretic properties, see [32A22](#)}
- 32H30** Value distribution theory in higher dimensions {For function-theoretic properties, see [32A22](#)}
- 32H35** Proper holomorphic mappings, finiteness theorems
- 32H40** Boundary regularity of mappings in several complex variables
- 32H50** Iteration of holomorphic maps, fixed points of holomorphic maps and related problems for several complex variables
- 32H99** None of the above, but in this section

## **32Jxx Compact analytic spaces {For Riemann surfaces, see [14Hxx](#), [30Fxx](#); for algebraic theory, see [14Jxx](#)}**

- 32J05** Compactification of analytic spaces
- 32J10** Algebraic dependence theorems
- 32J15** Compact complex surfaces
- 32J17** Compact complex 3-folds
- 32J18** Compact complex  $n$ -folds
- 32J25** Transcendental methods of algebraic geometry (complex-analytic aspects) [See also [14C30](#)]
- 32J27** Compact Kähler manifolds: generalizations, classification
- 32J81** Applications of compact analytic spaces to the sciences
- 32J99** None of the above, but in this section

## **32Kxx Generalizations of analytic spaces**

- 32K05** Banach analytic manifolds and spaces [See also [46G20](#), [58Bxx](#)]
- 32K07** Formal and graded complex spaces [See also [58C50](#)]
- 32K12** Holomorphic maps with infinite-dimensional arguments or values [See also [46G20](#)]
- 32K15** Differentiable functions on analytic spaces, differentiable spaces [See also [58C25](#)]
- 32K99** None of the above, but in this section

## **32Lxx Holomorphic fiber spaces [See also [55Rxx](#)]**

- 32L05** Holomorphic bundles and generalizations
- 32L10** Sheaves and cohomology of sections of holomorphic vector bundles, general results [See also [14F06](#), [14H60](#), [14J60](#), [18F20](#), [55N30](#)]
- 32L15** Bundle convexity [See also [32F10](#)]
- 32L20** Vanishing theorems
- 32L25** Twistor theory, double fibrations (complex-analytic aspects) [See also [53C28](#)]
- 32L81** Applications of holomorphic fiber spaces to the sciences
- 32L99** None of the above, but in this section

## **32Mxx Complex spaces with a group of automorphisms**

- 32M05** Complex Lie groups, group actions on complex spaces [See also [22E10](#)]
- 32M10** Homogeneous complex manifolds [See also [14M17](#), [57T15](#)]
- 32M12** Almost homogeneous manifolds and spaces [See also [14M17](#)]
- 32M15** Hermitian symmetric spaces, bounded symmetric domains, Jordan algebras (complex-analytic aspects) [See also [22E10](#), [22E40](#), [53C35](#), [57T15](#)]
- 32M17** Automorphism groups of  $\mathbb{C}^n$  and affine manifolds
- 32M18** Automorphism groups of other complex spaces
- 32M25** Complex vector fields, holomorphic foliations,  $\mathbb{C}$ -actions
- 32M99** None of the above, but in this section

## **32Nxx Automorphic functions [See also [11Fxx](#), [20H10](#), [22E40](#), [30F35](#)]**

- 32N05** General theory of automorphic functions of several complex variables
- 32N10** Automorphic forms in several complex variables
- 32N15** Automorphic functions in symmetric domains
- 32N99** None of the above, but in this section



## **32Pxx Non-Archimedean analysis (should also be assigned at least one other classification number from Section 32 describing the type of problem)**

**32P05** Non-Archimedean analysis (should also be assigned at least one other classification number from Section 32 describing the type of problem)

**32P99** None of the above, but in this section

## **32Qxx Complex manifolds**

**32Q02** Special domains (Reinhardt, Hartogs, circular, tube, etc.) in  $\mathbb{C}^n$  and complex manifolds

**32Q05** Negative curvature complex manifolds

**32Q10** Positive curvature complex manifolds

**32Q15** Kähler manifolds

**32Q20** Kähler-Einstein manifolds [See also [53Cxx](#)]

**32Q25** Calabi-Yau theory (complex-analytic aspects) [See also [14J32](#)]

**32Q26** Notions of stability for complex manifolds

**32Q28** Stein manifolds

**32Q30** Uniformization of complex manifolds

**32Q35** Complex manifolds as subdomains of Euclidean space

**32Q40** Embedding theorems for complex manifolds

**32Q45** Hyperbolic and Kobayashi hyperbolic manifolds

**32Q55** Topological aspects of complex manifolds

**32Q56** Oka principle and Oka manifolds

**32Q57** Classification theorems for complex manifolds

**32Q60** Almost complex manifolds

**32Q65** Pseudoholomorphic curves

**32Q99** None of the above, but in this section

## **32Sxx Complex singularities [See also [58Kxx](#)]**

**32S05** Local complex singularities [See also [14J17](#)]

**32S10** Invariants of analytic local rings

**32S15** Equisingularity (topological and analytic) [See also [14E15](#)]

**32S20** Global theory of complex singularities; cohomological properties [See also [14E15](#)]

**32S22** Relations with arrangements of hyperplanes [See also [52C35](#)]

**32S25** Complex surface and hypersurface singularities [See also [14J17](#)]

**32S30** Deformations of complex singularities; vanishing cycles [See also [14B07](#)]

**32S35** Mixed Hodge theory of singular varieties (complex-analytic aspects) [See also [14C30](#), [14D07](#)]

**32S40** Monodromy; relations with differential equations and  $D$ -modules (complex-analytic aspects)

**32S45** Modifications; resolution of singularities (complex-analytic aspects) [See also [14E15](#)]

**32S50** Topological aspects of complex singularities: Lefschetz theorems, topological classification, invariants

**32S55** Milnor fibration; relations with knot theory [See also [57K10](#), [57K45](#)]

**32S60** Stratifications; constructible sheaves; intersection cohomology (complex-analytic aspects) [See also [58Kxx](#)]

**32S65** Singularities of holomorphic vector fields and foliations

**32S70** Other operations on complex singularities

**32S99** None of the above, but in this section

## **32Txx Pseudoconvex domains**

**32T05** Domains of holomorphy

**32T15** Strongly pseudoconvex domains

**32T20** Worm domains

**32T25** Finite-type domains

**32T27** Geometric and analytic invariants on weakly pseudoconvex boundaries

**32T35** Exhaustion functions

**32T40** Peak functions

**32T99** None of the above, but in this section

## **32Uxx Pluripotential theory**

**32U05** Plurisubharmonic functions and generalizations [See also [31C10](#)]

**32U10** Plurisubharmonic exhaustion functions

**32U15** General pluripotential theory

**32U20** Capacity theory and generalizations

**32U25** Lelong numbers

**32U30** Removable sets in pluripotential theory

**32U35** Plurisubharmonic extremal functions, pluricomplex Green functions

**32U40** Currents

**32U99** None of the above, but in this section

## **32Vxx CR manifolds**

**32V05** CR structures, CR operators, and generalizations

**32V10** CR functions

**32V15** CR manifolds as boundaries of domains

**32V20** Analysis on CR manifolds

**32V25** Extension of functions and other analytic objects from CR manifolds

**32V30** Embeddings of CR manifolds

**32V35** Finite-type conditions on CR manifolds

**32V40** Real submanifolds in complex manifolds

**32V99** None of the above, but in this section

## 32Wxx Differential operators in several variables

- 32W05  $\bar{\partial}$  and  $\bar{\partial}$ -Neumann operators
- 32W10  $\bar{\partial}_b$  and  $\bar{\partial}_b$ -Neumann operators
- 32W20 Complex Monge-Ampère operators
- 32W25 Pseudodifferential operators in several complex variables
- 32W30 Heat kernels in several complex variables
- 32W50 Other partial differential equations of complex analysis in several variables
- 32W99 None of the above, but in this section

## 33-XX Special functions (33-XX deals with the properties of functions as functions) {For orthogonal functions, see 42Cxx; for aspects of combinatorics, see 05Axx; for number-theoretic aspects, see 11-XX; for representation theory, see 22Exx}

- 33-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to special functions
- 33-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to special functions
- 33-02 Research exposition (monographs, survey articles) pertaining to special functions
- 33-03 History of special functions [Consider also classification numbers pertaining to Section 01]
- 33-04 Software, source code, etc. for problems pertaining to special functions
- 33-06 Proceedings, conferences, collections, etc. pertaining to special functions
- 33-11 Research data for problems pertaining to special functions

## 33Bxx Elementary classical functions

- 33B10 Exponential and trigonometric functions
- 33B15 Gamma, beta and polygamma functions
- 33B20 Incomplete beta and gamma functions (error functions, probability integral, Fresnel integrals)
- 33B30 Higher logarithm functions
- 33B99 None of the above, but in this section

## 33Cxx Hypergeometric functions

- 33C05 Classical hypergeometric functions,  ${}_2F_1$
- 33C10 Bessel and Airy functions, cylinder functions,  ${}_0F_1$
- 33C15 Confluent hypergeometric functions, Whittaker functions,  ${}_1F_1$
- 33C20 Generalized hypergeometric series,  ${}_pF_q$
- 33C45 Orthogonal polynomials and functions of hypergeometric type (Jacobi, Laguerre, Hermite, Askey scheme, etc.) {For general orthogonal polynomials and functions, see also 42C05}
- 33C47 Other special orthogonal polynomials and functions
- 33C50 Orthogonal polynomials and functions in several variables expressible in terms of special functions in one variable
- 33C52 Orthogonal polynomials and functions associated with root systems
- 33C55 Spherical harmonics
- 33C60 Hypergeometric integrals and functions defined by them ( $E$ ,  $G$ ,  $H$  and  $I$  functions)
- 33C65 Appell, Horn and Lauricella functions
- 33C67 Hypergeometric functions associated with root systems
- 33C70 Other hypergeometric functions and integrals in several variables
- 33C75 Elliptic integrals as hypergeometric functions
- 33C80 Connections of hypergeometric functions with groups and algebras, and related topics
- 33C90 Applications of hypergeometric functions
- 33C99 None of the above, but in this section

## 33Dxx Basic hypergeometric functions

- 33D05  $q$ -gamma functions,  $q$ -beta functions and integrals
- 33D15 Basic hypergeometric functions in one variable,  ${}_r\phi_s$
- 33D45 Basic orthogonal polynomials and functions (Askey-Wilson polynomials, etc.)
- 33D50 Orthogonal polynomials and functions in several variables expressible in terms of basic hypergeometric functions in one variable
- 33D52 Basic orthogonal polynomials and functions associated with root systems (Macdonald polynomials, etc.)
- 33D60 Basic hypergeometric integrals and functions defined by them
- 33D65 Bibasic functions and multiple bases
- 33D67 Basic hypergeometric functions associated with root systems
- 33D70 Other basic hypergeometric functions and integrals in several variables
- 33D80 Connections of basic hypergeometric functions with quantum groups, Chevalley groups,  $p$ -adic groups, Hecke algebras, and related topics
- 33D90 Applications of basic hypergeometric functions
- 33D99 None of the above, but in this section

## 33E<sub>xx</sub> Other special functions

- 33E05 Elliptic functions and integrals
- 33E10 Lamé, Mathieu, and spheroidal wave functions
- 33E12 Mittag-Leffler functions and generalizations
- 33E15 Other wave functions
- 33E17 Painlevé-type functions
- 33E20 Other functions defined by series and integrals
- 33E30 Other functions coming from differential, difference and integral equations
- 33E50 Special functions in characteristic  $p$  (gamma functions, etc.)
- 33E99 None of the above, but in this section

## 33F<sub>xx</sub> Computational aspects of special functions {For software etc., see 33-04}

- 33F05 Numerical approximation and evaluation of special functions [See also 65D20]
- 33F10 Symbolic computation of special functions (Gosper and Zeilberger algorithms, etc.) [See also 68W30]
- 33F99 None of the above, but in this section

## 34-XX Ordinary differential equations

- 34-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to ordinary differential equations
- 34-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to ordinary differential equations
- 34-02 Research exposition (monographs, survey articles) pertaining to ordinary differential equations
- 34-03 History of ordinary differential equations [Consider also classification numbers pertaining to Section 01]
- 34-04 Software, source code, etc. for problems pertaining to ordinary differential equations
- 34-06 Proceedings, conferences, collections, etc. pertaining to ordinary differential equations
- 34-11 Research data for problems pertaining to ordinary differential equations

## 34A<sub>xx</sub> General theory for ordinary differential equations

- 34A05 Explicit solutions, first integrals of ordinary differential equations
- 34A06 Generalized ordinary differential equations (measure-differential equations, set-valued differential equations, etc.)
- 34A07 Fuzzy ordinary differential equations

- 34A08 Fractional ordinary differential equations and fractional differential inclusions
- 34A09 Implicit ordinary differential equations, differential-algebraic equations
- 34A12 Initial value problems, existence, uniqueness, continuous dependence and continuation of solutions to ordinary differential equations
- 34A25 Analytical theory of ordinary differential equations: series, transformations, transforms, operational calculus, etc. [See also 44-XX]
- 34A26 Geometric methods in ordinary differential equations
- 34A30 Linear ordinary differential equations and systems, general
- 34A33 Ordinary lattice differential equations
- 34A34 Nonlinear ordinary differential equations and systems, general theory
- 34A35 Ordinary differential equations of infinite order
- 34A36 Discontinuous ordinary differential equations
- 34A37 Ordinary differential equations with impulses
- 34A38 Hybrid systems of ordinary differential equations
- 34A40 Differential inequalities involving functions of a single real variable [See also 26D20]
- 34A45 Theoretical approximation of solutions to ordinary differential equations {For numerical analysis, see 65L<sub>xx</sub>}
- 34A55 Inverse problems involving ordinary differential equations
- 34A60 Ordinary differential inclusions [See also 49J21, 49K21]
- 34A99 None of the above, but in this section

## 34B<sub>xx</sub> Boundary value problems for ordinary differential equations {For ordinary differential operators, see 34L<sub>xx</sub>}

- 34B05 Linear boundary value problems for ordinary differential equations
- 34B07 Linear boundary value problems for ordinary differential equations with nonlinear dependence on the spectral parameter
- 34B08 Parameter dependent boundary value problems for ordinary differential equations
- 34B09 Boundary eigenvalue problems for ordinary differential equations
- 34B10 Nonlocal and multipoint boundary value problems for ordinary differential equations
- 34B15 Nonlinear boundary value problems for ordinary differential equations
- 34B16 Singular nonlinear boundary value problems for ordinary differential equations
- 34B18 Positive solutions to nonlinear boundary value problems for ordinary differential equations

- 34B20** Weyl theory and its generalizations for ordinary differential equations
- 34B24** Sturm-Liouville theory [See also [34Lxx](#)]
- 34B27** Green's functions for ordinary differential equations
- 34B30** Special ordinary differential equations (Mathieu, Hill, Bessel, etc.)
- 34B37** Boundary value problems with impulses for ordinary differential equations
- 34B40** Boundary value problems on infinite intervals for ordinary differential equations
- 34B45** Boundary value problems on graphs and networks for ordinary differential equations
- 34B60** Applications of boundary value problems involving ordinary differential equations
- 34B99** None of the above, but in this section
- 34Cxx Qualitative theory for ordinary differential equations** [See also [37-XX](#)]
- 34C05** Topological structure of integral curves, singular points, limit cycles of ordinary differential equations
- 34C07** Theory of limit cycles of polynomial and analytic vector fields (existence, uniqueness, bounds, Hilbert's 16th problem and ramifications) for ordinary differential equations
- 34C08** Ordinary differential equations and connections with real algebraic geometry (fewnomials, desingularization, zeros of abelian integrals, etc.)
- 34C10** Oscillation theory, zeros, disconjugacy and comparison theory for ordinary differential equations
- 34C11** Growth and boundedness of solutions to ordinary differential equations
- 34C12** Monotone systems involving ordinary differential equations
- 34C14** Symmetries, invariants of ordinary differential equations
- 34C15** Nonlinear oscillations and coupled oscillators for ordinary differential equations
- 34C20** Transformation and reduction of ordinary differential equations and systems, normal forms
- 34C23** Bifurcation theory for ordinary differential equations [See also [37Gxx](#)]
- 34C25** Periodic solutions to ordinary differential equations
- 34C26** Relaxation oscillations for ordinary differential equations
- 34C27** Almost and pseudo-almost periodic solutions to ordinary differential equations
- 34C28** Complex behavior and chaotic systems of ordinary differential equations [See also [37Dxx](#)]
- 34C29** Averaging method for ordinary differential equations
- 34C37** Homoclinic and heteroclinic solutions to ordinary differential equations
- 34C40** Ordinary differential equations and systems on manifolds
- 34C41** Equivalence and asymptotic equivalence of ordinary differential equations
- 34C45** Invariant manifolds for ordinary differential equations
- 34C46** Multifrequency systems of ordinary differential equations
- 34C55** Hysteresis for ordinary differential equations
- 34C60** Qualitative investigation and simulation of ordinary differential equation models
- 34C99** None of the above, but in this section
- 34Dxx Stability theory for ordinary differential equations** [See also [37C75](#), [93Dxx](#)]
- 34D05** Asymptotic properties of solutions to ordinary differential equations
- 34D06** Synchronization of solutions to ordinary differential equations
- 34D08** Characteristic and Lyapunov exponents of ordinary differential equations
- 34D09** Dichotomy, trichotomy of solutions to ordinary differential equations
- 34D10** Perturbations of ordinary differential equations
- 34D15** Singular perturbations of ordinary differential equations
- 34D20** Stability of solutions to ordinary differential equations
- 34D23** Global stability of solutions to ordinary differential equations
- 34D30** Structural stability and analogous concepts of solutions to ordinary differential equations [See also [37C20](#)]
- 34D35** Stability of manifolds of solutions to ordinary differential equations
- 34D45** Attractors of solutions to ordinary differential equations [See also [37C70](#), [37D45](#)]
- 34D99** None of the above, but in this section
- 34Exx Asymptotic theory for ordinary differential equations**
- 34E05** Asymptotic expansions of solutions to ordinary differential equations
- 34E10** Perturbations, asymptotics of solutions to ordinary differential equations
- 34E13** Multiple scale methods for ordinary differential equations
- 34E15** Singular perturbations, general theory for ordinary differential equations

- 34E17** Canard solutions to ordinary differential equations
- 34E18** Methods of nonstandard analysis for ordinary differential equations
- 34E20** Singular perturbations, turning point theory, WKB methods for ordinary differential equations
- 34E99** None of the above, but in this section
- 34Fxx Ordinary differential equations and systems with randomness** [See also [34K50](#), [60H10](#), [93E03](#)]
- 34F05** Ordinary differential equations and systems with randomness [See also [34K50](#), [60H10](#), [93E03](#)]
- 34F10** Bifurcation of solutions to ordinary differential equations involving randomness
- 34F15** Resonance phenomena for ordinary differential equations involving randomness
- 34F99** None of the above, but in this section
- 34Gxx Differential equations in abstract spaces** [See also [34Lxx](#), [37Kxx](#), [47Dxx](#), [47Hxx](#), [47Jxx](#), [58D25](#)]
- 34G10** Linear differential equations in abstract spaces [See also [47D06](#), [47D09](#)]
- 34G20** Nonlinear differential equations in abstract spaces [See also [47Hxx](#), [47Jxx](#)]
- 34G25** Evolution inclusions
- 34G99** None of the above, but in this section
- 34Hxx Control problems including ordinary differential equations** [See also [49J15](#), [49K15](#), [93C15](#)]
- 34H05** Control problems involving ordinary differential equations [See also [49J15](#), [49K15](#), [93C15](#)]
- 34H10** Chaos control for problems involving ordinary differential equations
- 34H15** Stabilization of solutions to ordinary differential equations
- 34H20** Bifurcation control of ordinary differential equations
- 34H99** None of the above, but in this section
- 34Kxx Functional-differential equations (including equations with delayed, advanced or state-dependent argument)**
- 34K04** Symmetries, invariants of functional-differential equations [See also [37C80](#)]
- 34K05** General theory of functional-differential equations
- 34K06** Linear functional-differential equations
- 34K07** Theoretical approximation of solutions to functional-differential equations
- 34K08** Spectral theory of functional-differential operators
- 34K09** Functional-differential inclusions
- 34K10** Boundary value problems for functional-differential equations
- 34K11** Oscillation theory of functional-differential equations
- 34K12** Growth, boundedness, comparison of solutions to functional-differential equations [See also [37C35](#)]
- 34K13** Periodic solutions to functional-differential equations [See also [37C27](#)]
- 34K14** Almost and pseudo-almost periodic solutions to functional-differential equations
- 34K16** Heteroclinic and homoclinic orbits of functional-differential equations [See also [37C29](#)]
- 34K17** Transformation and reduction of functional-differential equations and systems, normal forms
- 34K18** Bifurcation theory of functional-differential equations [See also [37Gxx](#)]
- 34K19** Invariant manifolds of functional-differential equations
- 34K20** Stability theory of functional-differential equations [See also [37C75](#)]
- 34K21** Stationary solutions of functional-differential equations
- 34K23** Complex (chaotic) behavior of solutions to functional-differential equations [See also [37D45](#)]
- 34K24** Synchronization of functional-differential equations
- 34K25** Asymptotic theory of functional-differential equations
- 34K26** Singular perturbations of functional-differential equations
- 34K27** Perturbations of functional-differential equations
- 34K29** Inverse problems for functional-differential equations
- 34K30** Functional-differential equations in abstract spaces [See also [34Gxx](#), [35R09](#), [35R10](#), [47Jxx](#)]
- 34K31** Lattice functional-differential equations
- 34K32** Implicit functional-differential equations
- 34K33** Averaging for functional-differential equations
- 34K34** Hybrid systems of functional-differential equations
- 34K35** Control problems for functional-differential equations [See also [49J21](#), [49K21](#), [93C23](#)]
- 34K36** Fuzzy functional-differential equations
- 34K37** Functional-differential equations with fractional derivatives
- 34K38** Functional-differential inequalities
- 34K39** Discontinuous functional-differential equations
- 34K40** Neutral functional-differential equations
- 34K41** Functional-differential equations in the complex domain



- 34K42** Functional-differential equations on time scales or measure chains
- 34K43** Functional-differential equations with state-dependent arguments
- 34K45** Functional-differential equations with impulses
- 34K50** Stochastic functional-differential equations [See also [34Fxx](#), [60Hxx](#)]
- 34K60** Qualitative investigation and simulation of models involving functional-differential equations
- 34K99** None of the above, but in this section
- 34Lxx Ordinary differential operators** [See also [47E05](#)]
- 34L05** General spectral theory of ordinary differential operators
- 34L10** Eigenfunctions, eigenfunction expansions, completeness of eigenfunctions of ordinary differential operators
- 34L15** Eigenvalues, estimation of eigenvalues, upper and lower bounds of ordinary differential operators
- 34L16** Numerical approximation of eigenvalues and of other parts of the spectrum of ordinary differential operators
- 34L20** Asymptotic distribution of eigenvalues, asymptotic theory of eigenfunctions for ordinary differential operators
- 34L25** Scattering theory, inverse scattering involving ordinary differential operators
- 34L30** Nonlinear ordinary differential operators
- 34L40** Particular ordinary differential operators (Dirac, one-dimensional Schrödinger, etc.)
- 34L99** None of the above, but in this section
- 34Mxx Ordinary differential equations in the complex domain** [See also [30Dxx](#), [32G34](#)]
- 34M03** Linear ordinary differential equations and systems in the complex domain
- 34M04** Nonlinear ordinary differential equations and systems in the complex domain
- 34M05** Entire and meromorphic solutions to ordinary differential equations in the complex domain
- 34M10** Oscillation, growth of solutions to ordinary differential equations in the complex domain
- 34M15** Algebraic aspects (differential-algebraic, hypertranscendence, group-theoretical) of ordinary differential equations in the complex domain
- 34M25** Formal solutions and transform techniques for ordinary differential equations in the complex domain
- 34M30** Asymptotics and summation methods for ordinary differential equations in the complex domain
- 34M35** Singularities, monodromy and local behavior of solutions to ordinary differential equations in the complex domain, normal forms
- 34M40** Stokes phenomena and connection problems (linear and nonlinear) for ordinary differential equations in the complex domain
- 34M45** Ordinary differential equations on complex manifolds
- 34M46** Spectral theory for ordinary differential operators in the complex domain
- 34M50** Inverse problems (Riemann-Hilbert, inverse differential Galois, etc.) for ordinary differential equations in the complex domain
- 34M55** Painlevé and other special ordinary differential equations in the complex domain; classification, hierarchies;
- 34M56** Isomonodromic deformations for ordinary differential equations in the complex domain
- 34M60** Singular perturbation problems for ordinary differential equations in the complex domain (complex WKB, turning points, steepest descent) [See also [34E20](#)]
- 34M65** Topological structure of trajectories of ordinary differential equations in the complex domain
- 34M99** None of the above, but in this section
- 34Nxx Dynamic equations on time scales or measure chains** {For real analysis on time scales, see [26E70](#)}
- 34N05** Dynamic equations on time scales or measure chains {For real analysis on time scales or measure chains, see [26E70](#)}
- 34N99** None of the above, but in this section
- 35-XX Partial differential equations**
- 35-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to partial differential equations
- 35-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to partial differential equations
- 35-02** Research exposition (monographs, survey articles) pertaining to partial differential equations
- 35-03** History of partial differential equations [Consider also classification numbers pertaining to Section [01](#)]
- 35-04** Software, source code, etc. for problems pertaining to partial differential equations
- 35-06** Proceedings, conferences, collections, etc. pertaining to partial differential equations
- 35-11** Research data for problems pertaining to partial differential equations



## 35Axx General topics in partial differential equations

- 35A01 Existence problems for PDEs: global existence, local existence, non-existence
- 35A02 Uniqueness problems for PDEs: global uniqueness, local uniqueness, non-uniqueness
- 35A08 Fundamental solutions to PDEs
- 35A09 Classical solutions to PDEs
- 35A10 Cauchy-Kovalevskaya theorems
- 35A15 Variational methods applied to PDEs
- 35A16 Topological and monotonicity methods applied to PDEs
- 35A17 Parametrices in context of PDEs
- 35A18 Wave front sets in context of PDEs
- 35A20 Analyticity in context of PDEs
- 35A21 Singularity in context of PDEs
- 35A22 Transform methods (e.g., integral transforms) applied to PDEs
- 35A23 Inequalities applied to PDEs involving derivatives, differential and integral operators, or integrals
- 35A24 Methods of ordinary differential equations applied to PDEs
- 35A25 Other special methods applied to PDEs
- 35A27 Microlocal methods and methods of sheaf theory and homological algebra applied to PDEs [See also 32C38, 58J15]
- 35A30 Geometric theory, characteristics, transformations in context of PDEs [See also 58J70, 58J72]
- 35A35 Theoretical approximation in context of PDEs {For numerical analysis, see 65Mxx, 65Nxx}
- 35A99 None of the above, but in this section

## 35Bxx Qualitative properties of solutions to partial differential equations

- 35B05 Oscillation, zeros of solutions, mean value theorems, etc. in context of PDEs
- 35B06 Symmetries, invariants, etc. in context of PDEs
- 35B07 Axially symmetric solutions to PDEs
- 35B08 Entire solutions to PDEs
- 35B09 Positive solutions to PDEs
- 35B10 Periodic solutions to PDEs
- 35B15 Almost and pseudo-almost periodic solutions to PDEs
- 35B20 Perturbations in context of PDEs
- 35B25 Singular perturbations in context of PDEs
- 35B27 Homogenization in context of PDEs; PDEs in media with periodic structure [See also 74Q05, 74Q10, 76M50, 78M40, 80M40]

- 35B30 Dependence of solutions to PDEs on initial and/or boundary data and/or on parameters of PDEs [See also 37Cxx]
- 35B32 Bifurcations in context of PDEs [See also 34C23, 34F10, 34H20, 37F46, 37Gxx, 37H20, 35J20, 37L10, 37M20, 47J15, 58E05, 58E07, 58J55, 74G60, 74H60]
- 35B33 Critical exponents in context of PDEs
- 35B34 Resonance in context of PDEs [See also 34F15, 70J40, 70K28, 70K30, 81U24]
- 35B35 Stability in context of PDEs [See also 34Dxx, 37B25, 37C20, 37C75, 37F15, 37J25, 37K45, 37L15, 49K40, 58K25, 93Dxx]
- 35B36 Pattern formations in context of PDEs [See also 92C15]
- 35B38 Critical points of functionals in context of PDEs (e.g., energy functionals) [See also 57R70, 58K05, 58E05]
- 35B40 Asymptotic behavior of solutions to PDEs
- 35B41 Attractors [See also 34D45, 37B35, 37C70, 37D45, 37G35, 37L30, 37M22]
- 35B42 Inertial manifolds [See also 37L25]
- 35B44 Blow-up in context of PDEs
- 35B45 A priori estimates in context of PDEs
- 35B50 Maximum principles in context of PDEs
- 35B51 Comparison principles in context of PDEs
- 35B53 Liouville theorems and Phragmén-Lindelöf theorems in context of PDEs
- 35B60 Continuation and prolongation of solutions to PDEs [See also 58A15, 58A17, 58Hxx]
- 35B65 Smoothness and regularity of solutions to PDEs
- 35B99 None of the above, but in this section

## 35Cxx Representations of solutions to partial differential equations

- 35C05 Solutions to PDEs in closed form
- 35C06 Self-similar solutions to PDEs
- 35C07 Traveling wave solutions
- 35C08 Soliton solutions [See also 37K40]
- 35C09 Trigonometric solutions to PDEs
- 35C10 Series solutions to PDEs
- 35C11 Polynomial solutions to PDEs
- 35C15 Integral representations of solutions to PDEs
- 35C20 Asymptotic expansions of solutions to PDEs
- 35C99 None of the above, but in this section

## 35Dxx Generalized solutions to partial differential equations

- 35D30 Weak solutions to PDEs
- 35D35 Strong solutions to PDEs
- 35D40 Viscosity solutions to PDEs
- 35D99 None of the above, but in this section

## **35Exx Partial differential equations and systems of partial differential equations with constant coefficients [See also 35N05]**

- 35E05** Fundamental solutions to PDEs and systems of PDEs with constant coefficients
- 35E10** Convexity properties of solutions to PDEs and systems of PDEs with constant coefficients
- 35E15** Initial value problems for PDEs and systems of PDEs with constant coefficients
- 35E20** General theory of PDEs and systems of PDEs with constant coefficients
- 35E99** None of the above, but in this section

## **35Fxx General first-order partial differential equations and systems of first-order partial differential equations**

- 35F05** Linear first-order PDEs
- 35F10** Initial value problems for linear first-order PDEs
- 35F15** Boundary value problems for linear first-order PDEs
- 35F16** Initial-boundary value problems for linear first-order PDEs
- 35F20** Nonlinear first-order PDEs
- 35F21** Hamilton-Jacobi equations {For calculus of variations and optimal control, see 49Lxx; for mechanics of particles and systems, see 70H20}
- 35F25** Initial value problems for nonlinear first-order PDEs
- 35F30** Boundary value problems for nonlinear first-order PDEs
- 35F31** Initial-boundary value problems for nonlinear first-order PDEs
- 35F35** Systems of linear first-order PDEs
- 35F40** Initial value problems for systems of linear first-order PDEs
- 35F45** Boundary value problems for systems of linear first-order PDEs
- 35F46** Initial-boundary value problems for systems of linear first-order PDEs
- 35F50** Systems of nonlinear first-order PDEs
- 35F55** Initial value problems for systems of nonlinear first-order PDEs
- 35F60** Boundary value problems for systems of nonlinear first-order PDEs
- 35F61** Initial-boundary value problems for systems of nonlinear first-order PDEs
- 35F99** None of the above, but in this section

## **35Gxx General higher-order partial differential equations and systems of higher-order partial differential equations**

- 35G05** Linear higher-order PDEs
- 35G10** Initial value problems for linear higher-order PDEs
- 35G15** Boundary value problems for linear higher-order PDEs
- 35G16** Initial-boundary value problems for linear higher-order PDEs
- 35G20** Nonlinear higher-order PDEs
- 35G25** Initial value problems for nonlinear higher-order PDEs
- 35G30** Boundary value problems for nonlinear higher-order PDEs
- 35G31** Initial-boundary value problems for nonlinear higher-order PDEs
- 35G35** Systems of linear higher-order PDEs
- 35G40** Initial value problems for systems of linear higher-order PDEs
- 35G45** Boundary value problems for systems of linear higher-order PDEs
- 35G46** Initial-boundary value problems for systems of linear higher-order PDEs
- 35G50** Systems of nonlinear higher-order PDEs
- 35G55** Initial value problems for systems of nonlinear higher-order PDEs
- 35G60** Boundary value problems for systems of nonlinear higher-order PDEs
- 35G61** Initial-boundary value problems for systems of nonlinear higher-order PDEs
- 35G99** None of the above, but in this section

## **35Hxx Close-to-elliptic equations**

- 35H10** Hypoelliptic equations
- 35H20** Subelliptic equations
- 35H30** Quasielliptic equations
- 35H99** None of the above, but in this section

## **35Jxx Elliptic equations and elliptic systems {For global analysis, analysis on manifolds, see 58J10, 58J20}**

- 35J05** Laplace operator, Helmholtz equation (reduced wave equation), Poisson equation [See also 31Axx, 31Bxx]
- 35J08** Green's functions for elliptic equations
- 35J10** Schrödinger operator, Schrödinger equation {For ordinary differential equations, see 34L40; for operator theory, see 47D08; for quantum theory, see 81Q05; for statistical mechanics, see 82B44}

- 35J15** Second-order elliptic equations
- 35J20** Variational methods for second-order elliptic equations
- 35J25** Boundary value problems for second-order elliptic equations
- 35J30** Higher-order elliptic equations [See also [31A30](#), [31B30](#)]
- 35J35** Variational methods for higher-order elliptic equations
- 35J40** Boundary value problems for higher-order elliptic equations
- 35J46** First-order elliptic systems
- 35J47** Second-order elliptic systems
- 35J48** Higher-order elliptic systems
- 35J50** Variational methods for elliptic systems
- 35J56** Boundary value problems for first-order elliptic systems
- 35J57** Boundary value problems for second-order elliptic systems
- 35J58** Boundary value problems for higher-order elliptic systems
- 35J60** Nonlinear elliptic equations
- 35J61** Semilinear elliptic equations
- 35J62** Quasilinear elliptic equations
- 35J65** Nonlinear boundary value problems for linear elliptic equations
- 35J66** Nonlinear boundary value problems for nonlinear elliptic equations
- 35J67** Boundary values of solutions to elliptic equations and elliptic systems
- 35J70** Degenerate elliptic equations
- 35J75** Singular elliptic equations
- 35J86** Unilateral problems for linear elliptic equations and variational inequalities with linear elliptic operators [See also [35R35](#), [49J40](#)]
- 35J87** Unilateral problems for nonlinear elliptic equations and variational inequalities with nonlinear elliptic operators [See also [35R35](#), [49J40](#)]
- 35J88** Unilateral problems for elliptic systems and systems of variational inequalities with elliptic operators [See also [35R35](#), [49J40](#)]
- 35J91** Semilinear elliptic equations with Laplacian, bi-Laplacian or poly-Laplacian
- 35J92** Quasilinear elliptic equations with  $p$ -Laplacian
- 35J93** Quasilinear elliptic equations with mean curvature operator
- 35J94** Elliptic equations with infinity-Laplacian
- 35J96** Monge-Ampère equations {For complex Monge-Ampère operators, see [32W20](#); for parabolic Monge-Ampère equations, see [35K96](#)}
- 35J99** None of the above, but in this section
- 35Kxx** Parabolic equations and parabolic systems {For global analysis, analysis on manifolds, see [58J35](#)}
- 35K05** Heat equation
- 35K08** Heat kernel
- 35K10** Second-order parabolic equations
- 35K15** Initial value problems for second-order parabolic equations
- 35K20** Initial-boundary value problems for second-order parabolic equations
- 35K25** Higher-order parabolic equations
- 35K30** Initial value problems for higher-order parabolic equations
- 35K35** Initial-boundary value problems for higher-order parabolic equations
- 35K40** Second-order parabolic systems
- 35K41** Higher-order parabolic systems
- 35K45** Initial value problems for second-order parabolic systems
- 35K46** Initial value problems for higher-order parabolic systems
- 35K51** Initial-boundary value problems for second-order parabolic systems
- 35K52** Initial-boundary value problems for higher-order parabolic systems
- 35K55** Nonlinear parabolic equations
- 35K57** Reaction-diffusion equations {For diffusion processes and reaction effects, see [47D07](#), [58J65](#), [60J60](#), [60J70](#), [74N25](#), [76R50](#), [76V05](#), [80A23](#), [82B24](#), [82C24](#), [92E20](#)}
- 35K58** Semilinear parabolic equations
- 35K59** Quasilinear parabolic equations
- 35K60** Nonlinear initial, boundary and initial-boundary value problems for linear parabolic equations
- 35K61** Nonlinear initial, boundary and initial-boundary value problems for nonlinear parabolic equations
- 35K65** Degenerate parabolic equations
- 35K67** Singular parabolic equations
- 35K70** Ultraparabolic equations, pseudoparabolic equations, etc.
- 35K85** Unilateral problems for linear parabolic equations and variational inequalities with linear parabolic operators [See also [35R35](#), [49J40](#)]
- 35K86** Unilateral problems for nonlinear parabolic equations and variational inequalities with nonlinear parabolic operators [See also [35R35](#), [49J40](#)]
- 35K87** Unilateral problems for parabolic systems and systems of variational inequalities with parabolic operators [See also [35R35](#), [49J40](#)]
- 35K90** Abstract parabolic equations

- 35K91** Semilinear parabolic equations with Laplacian, bi-Laplacian or poly-Laplacian
- 35K92** Quasilinear parabolic equations with  $p$ -Laplacian
- 35K93** Quasilinear parabolic equations with mean curvature operator
- 35K96** Parabolic Monge-Ampère equations
- 35K99** None of the above, but in this section

## **35Lxx Hyperbolic equations and hyperbolic systems {For global analysis, see [58J45](#)}**

- 35L02** First-order hyperbolic equations
- 35L03** Initial value problems for first-order hyperbolic equations
- 35L04** Initial-boundary value problems for first-order hyperbolic equations
- 35L05** Wave equation
- 35L10** Second-order hyperbolic equations
- 35L15** Initial value problems for second-order hyperbolic equations
- 35L20** Initial-boundary value problems for second-order hyperbolic equations
- 35L25** Higher-order hyperbolic equations
- 35L30** Initial value problems for higher-order hyperbolic equations
- 35L35** Initial-boundary value problems for higher-order hyperbolic equations
- 35L40** First-order hyperbolic systems
- 35L45** Initial value problems for first-order hyperbolic systems
- 35L50** Initial-boundary value problems for first-order hyperbolic systems
- 35L51** Second-order hyperbolic systems
- 35L52** Initial value problems for second-order hyperbolic systems
- 35L53** Initial-boundary value problems for second-order hyperbolic systems
- 35L55** Higher-order hyperbolic systems
- 35L56** Initial value problems for higher-order hyperbolic systems
- 35L57** Initial-boundary value problems for higher-order hyperbolic systems
- 35L60** First-order nonlinear hyperbolic equations
- 35L65** Hyperbolic conservation laws
- 35L67** Shocks and singularities for hyperbolic equations [See also [58Kxx](#), [74J40](#), [76L05](#)]
- 35L70** Second-order nonlinear hyperbolic equations
- 35L71** Second-order semilinear hyperbolic equations

- 35L72** Second-order quasilinear hyperbolic equations
- 35L75** Higher-order nonlinear hyperbolic equations
- 35L76** Higher-order semilinear hyperbolic equations
- 35L77** Higher-order quasilinear hyperbolic equations
- 35L80** Degenerate hyperbolic equations
- 35L81** Singular hyperbolic equations
- 35L82** Pseudohyperbolic equations
- 35L85** Unilateral problems for linear hyperbolic equations and variational inequalities with linear hyperbolic operators [See also [35R35](#), [49J40](#)]
- 35L86** Unilateral problems for nonlinear hyperbolic equations and variational inequalities with nonlinear hyperbolic operators [See also [35R35](#), [49J40](#)]
- 35L87** Unilateral problems for hyperbolic systems and systems of variational inequalities with hyperbolic operators [See also [35R35](#), [49J40](#)]
- 35L90** Abstract hyperbolic equations
- 35L99** None of the above, but in this section

## **35Mxx Partial differential equations of mixed type and mixed-type systems of partial differential equations**

- 35M10** PDEs of mixed type
- 35M11** Initial value problems for PDEs of mixed type
- 35M12** Boundary value problems for PDEs of mixed type
- 35M13** Initial-boundary value problems for PDEs of mixed type
- 35M30** Mixed-type systems of PDEs
- 35M31** Initial value problems for mixed-type systems of PDEs
- 35M32** Boundary value problems for mixed-type systems of PDEs
- 35M33** Initial-boundary value problems for mixed-type systems of PDEs
- 35M85** Unilateral problems for linear PDEs of mixed type and variational inequalities with partial differential operators of mixed type [See also [35R35](#), [49J40](#)]
- 35M86** Unilateral problems for nonlinear PDEs of mixed type and variational inequalities with nonlinear partial differential operators of mixed type [See also [35R35](#), [49J40](#)]
- 35M87** Unilateral problems for mixed-type systems of PDEs and systems of variational inequalities with partial differential operators of mixed type [See also [35R35](#), [49J40](#)]
- 35M99** None of the above, but in this section

**35Nxx Overdetermined problems for partial differential equations and systems of partial differential equations {For global analysis, see 58Hxx, 58J10, 58J15}**

- 35N05 Overdetermined systems of PDEs with constant coefficients
- 35N10 Overdetermined systems of PDEs with variable coefficients
- 35N15  $\bar{\partial}$ -Neumann problems and formal complexes in context of PDEs [See also 32W05, 32W10, 58J10]
- 35N20 Overdetermined initial value problems for PDEs and systems of PDEs
- 35N25 Overdetermined boundary value problems for PDEs and systems of PDEs
- 35N30 Overdetermined initial-boundary value problems for PDEs and systems of PDEs
- 35N99 None of the above, but in this section

**35Pxx Spectral theory and eigenvalue problems for partial differential equations {For operator theory, see 47Axx, 47Bxx, 47F05}**

- 35P05 General topics in linear spectral theory for PDEs
- 35P10 Completeness of eigenfunctions and eigenfunction expansions in context of PDEs
- 35P15 Estimates of eigenvalues in context of PDEs
- 35P20 Asymptotic distributions of eigenvalues in context of PDEs
- 35P25 Scattering theory for PDEs [See also 47A40]
- 35P30 Nonlinear eigenvalue problems and nonlinear spectral theory for PDEs
- 35P99 None of the above, but in this section

**35Qxx Partial differential equations of mathematical physics and other areas of application [See also 35J05, 35J10, 35K05, 35L05]**

- 35Q05 Euler-Poisson-Darboux equations
- 35Q07 Fuchsian PDEs
- 35Q15 Riemann-Hilbert problems in context of PDEs [See also 30E25, 31A25, 31B20]
- 35Q20 Boltzmann equations {For fluid mechanics, see 76P05; for statistical mechanics, see 82B40, 82C40, 82D05}
- 35Q30 Navier-Stokes equations {For fluid mechanics, see 76D05, 76D07, 76N10}
- 35Q31 Euler equations {For fluid mechanics, see 76D05, 76D07, 76N10}

- 35Q35 PDEs in connection with fluid mechanics
- 35Q40 PDEs in connection with quantum mechanics
- 35Q41 Time-dependent Schrödinger equations and Dirac equations {For quantum theory, see 81Q05; for relativity and gravitational theory, see 83A05, 83C10}
- 35Q51 Soliton equations {For dynamical systems and ergodic theory, see 37K40}
- 35Q53 KdV equations (Korteweg-de Vries equations) {For dynamical systems and ergodic theory, see 37K10}
- 35Q55 NLS equations (nonlinear Schrödinger equations) {For dynamical systems and ergodic theory, see 37K10}
- 35Q56 Ginzburg-Landau equations {For optics and electromagnetic theory, see 78A25}
- 35Q60 PDEs in connection with optics and electromagnetic theory
- 35Q61 Maxwell equations {For optics and electromagnetic theory, see 78A25; for relativity and gravitational theory, see 83C22}
- 35Q62 PDEs in connection with statistics
- 35Q68 PDEs in connection with computer science
- 35Q70 PDEs in connection with mechanics of particles and systems of particles
- 35Q74 PDEs in connection with mechanics of deformable solids
- 35Q75 PDEs in connection with relativity and gravitational theory
- 35Q76 Einstein equations {For several complex variables and analytic spaces, see 32Q40; for differential geometry, see 53C07; for relativity and gravitational theory, see 83C05, 83C25, 83D05}
- 35Q79 PDEs in connection with classical thermodynamics and heat transfer
- 35Q80 Transport equations {For calculus of variations and optimal control, see 49Q20; for fluid mechanics, see 76F25; for statistical mechanics, see 82C70, 82D75; for operations research, see 90B06; for mathematical programming, see 90C08}
- 35Q81 PDEs in connection with semiconductor devices {For statistical mechanics, see 82D37}
- 35Q82 PDEs in connection with statistical mechanics
- 35Q83 Vlasov equations {For statistical mechanics, see 82C70, 82D75}
- 35Q84 Fokker-Planck equations {For fluid mechanics, see 76X05, 76W05; for statistical mechanics, see 82C31}
- 35Q85 PDEs in connection with astronomy and astrophysics
- 35Q86 PDEs in connection with geophysics
- 35Q89 PDEs in connection with mean field game theory {For calculus of variations and optimal control, see 49N80; for game theory, see 91A16}
- 35Q90 PDEs in connection with mathematical programming



- 35Q91** PDEs in connection with game theory, economics, social and behavioral sciences
- 35Q92** PDEs in connection with biology, chemistry and other natural sciences
- 35Q93** PDEs in connection with control and optimization
- 35Q94** PDEs in connection with information and communication
- 35Q99** None of the above, but in this section

**35Rxx Miscellaneous topics in partial differential equations {For equations on manifolds, see [32Wxx](#), [58Jxx](#); for manifolds of solutions, see [58Bxx](#); for stochastic PDEs, see [60H15](#)}**

- 35R01** PDEs on manifolds [See also [32Wxx](#), [53Cxx](#), [58Jxx](#)]
- 35R02** PDEs on graphs and networks (ramified or polygonal spaces)
- 35R03** PDEs on Heisenberg groups, Lie groups, Carnot groups, etc.
- 35R05** PDEs with low regular coefficients and/or low regular data
- 35R06** PDEs with measure
- 35R07** PDEs on time scales
- 35R09** Integral partial differential equations [See also [45Kxx](#)]
- 35R10** Functional partial differential equations
- 35R11** Fractional partial differential equations
- 35R12** Impulsive partial differential equations
- 35R13** Fuzzy partial differential equations
- 35R15** PDEs on infinite-dimensional (e.g., function) spaces (= PDEs in infinitely many variables) [See also [46Gxx](#), [58D25](#)]
- 35R20** Operator partial differential equations (= PDEs on finite-dimensional spaces for abstract space valued functions) [See also [34Gxx](#), [47A50](#), [47D03](#), [47D06](#), [47D09](#), [47H20](#), [47Jxx](#)]
- 35R25** Ill-posed problems for PDEs
- 35R30** Inverse problems for PDEs
- 35R35** Free boundary problems for PDEs
- 35R37** Moving boundary problems for PDEs
- 35R45** Partial differential inequalities and systems of partial differential inequalities
- 35R50** PDEs of infinite order
- 35R60** PDEs with randomness, stochastic partial differential equations [See also [60H15](#)]
- 35R70** PDEs with multivalued right-hand sides
- 35R99** None of the above, but in this section

**35Sxx Pseudodifferential operators and other generalizations of partial differential operators {For operator theory, see [47G30](#), [58J40](#)}**

- 35S05** Pseudodifferential operators as generalizations of partial differential operators [See also [32W25](#), [47G30](#), [47L80](#), [58J40](#)]
- 35S10** Initial value problems for PDEs with pseudodifferential operators
- 35S15** Boundary value problems for PDEs with pseudodifferential operators
- 35S16** Initial-boundary value problems for PDEs with pseudodifferential operators
- 35S30** Fourier integral operators applied to PDEs [See also [43A32](#), [58J40](#)]
- 35S35** Topological aspects for pseudodifferential operators in context of PDEs: intersection cohomology, stratified sets, etc. [See also [32C38](#), [32S40](#), [32S60](#), [58J15](#)]
- 35S50** Paradifferential operators as generalizations of partial differential operators in context of PDEs
- 35S99** None of the above, but in this section

**37-XX Dynamical systems and ergodic theory [See also [26A18](#), [28Dxx](#), [34Cxx](#), [34Dxx](#), [35Bxx](#), [46Lxx](#), [58Jxx](#), [70-XX](#)]**

- 37-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to dynamical systems and ergodic theory
- 37-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to dynamical systems and ergodic theory
- 37-02** Research exposition (monographs, survey articles) pertaining to dynamical systems and ergodic theory
- 37-03** History of dynamical systems and ergodic theory [Consider also classification numbers pertaining to Section [01](#)]
- 37-04** Software, source code, etc. for problems pertaining to dynamical systems and ergodic theory
- 37-06** Proceedings, conferences, collections, etc. pertaining to dynamical systems and ergodic theory
- 37-11** Research data for problems pertaining to dynamical systems and ergodic theory



## **37Axx Ergodic theory [See also 28Dxx]**

- 37A05** Dynamical aspects of measure-preserving transformations
- 37A10** Dynamical systems involving one-parameter continuous families of measure-preserving transformations
- 37A15** General groups of measure-preserving transformations and dynamical systems [See mainly 22Fxx]
- 37A17** Homogeneous flows [See also 22Fxx]
- 37A20** Algebraic ergodic theory, cocycles, orbit equivalence, ergodic equivalence relations
- 37A25** Ergodicity, mixing, rates of mixing
- 37A30** Ergodic theorems, spectral theory, Markov operators {For operator ergodic theory, see mainly 47A35}
- 37A35** Entropy and other invariants, isomorphism, classification in ergodic theory
- 37A40** Nonsingular (and infinite-measure preserving) transformations
- 37A45** Relations between ergodic theory and number theory [See also 11Kxx]
- 37A46** Relations between ergodic theory and harmonic analysis
- 37A50** Dynamical systems and their relations with probability theory and stochastic processes [See also 60Fxx, 60G10]
- 37A55** Dynamical systems and the theory of  $C^*$ -algebras [See mainly 46L55]
- 37A60** Dynamical aspects of statistical mechanics [See also 82Cxx]
- 37A99** None of the above, but in this section

## **37Bxx Topological dynamics**

- 37B02** Dynamics in general topological spaces
- 37B05** Dynamical systems involving transformations and group actions with special properties (minimality, distality, proximality, expansivity, etc.)
- 37B10** Symbolic dynamics
- 37B15** Dynamical aspects of cellular automata {For computational aspects, see 68Q80}
- 37B20** Notions of recurrence and recurrent behavior in dynamical systems
- 37B25** Stability of topological dynamical systems
- 37B30** Index theory for dynamical systems, Morse-Conley indices
- 37B35** Gradient-like and recurrent behavior; isolated (locally maximal) invariant sets; attractors, repellers for topological dynamical systems
- 37B40** Topological entropy
- 37B45** Continua theory in dynamics
- 37B50** Multidimensional shifts of finite type

**37B52** Tiling dynamics

**37B55** Topological dynamics of nonautonomous systems

**37B65** Approximate trajectories, pseudotrajectories, shadowing and related notions for topological dynamical systems

**37B99** None of the above, but in this section

## **37Cxx Smooth dynamical systems: general theory [See also 34Cxx, 34Dxx]**

**37C05** Dynamical systems involving smooth mappings and diffeomorphisms

**37C10** Dynamics induced by flows and semiflows

**37C15** Topological and differentiable equivalence, conjugacy, moduli, classification of dynamical systems

**37C20** Generic properties, structural stability of dynamical systems

**37C25** Fixed points and periodic points of dynamical systems; fixed-point index theory, local dynamics

**37C27** Periodic orbits of vector fields and flows

**37C29** Homoclinic and heteroclinic orbits for dynamical systems

**37C30** Functional analytic techniques in dynamical systems; zeta functions, (Ruelle-Frobenius) transfer operators, etc.

**37C35** Orbit growth in dynamical systems

**37C40** Smooth ergodic theory, invariant measures for smooth dynamical systems [See also 37Dxx]

**37C45** Dimension theory of smooth dynamical systems

**37C50** Approximate trajectories (pseudotrajectories, shadowing, etc.) in smooth dynamics

**37C55** Periodic and quasi-periodic flows and diffeomorphisms

**37C60** Nonautonomous smooth dynamical systems [See also 37B55]

**37C65** Monotone flows as dynamical systems

**37C70** Attractors and repellers of smooth dynamical systems and their topological structure

**37C75** Stability theory for smooth dynamical systems

**37C80** Symmetries and invariants of dynamical systems

**37C81** Equivariant dynamical systems

**37C83** Dynamical systems with singularities (billiards, etc.)

**37C85** Dynamics induced by group actions other than  $\mathbb{Z}$  and  $\mathbb{R}$ , and  $\mathbb{C}$  [See mainly 22Fxx, and also 32M25, 57R30, 57Sxx]

**37C86** Foliations generated by dynamical systems

**37C99** None of the above, but in this section

## **37Dxx Dynamical systems with hyperbolic behavior**

- 37D05** Dynamical systems with hyperbolic orbits and sets
- 37D10** Invariant manifold theory for dynamical systems
- 37D15** Morse-Smale systems
- 37D20** Uniformly hyperbolic systems (expanding, Anosov, Axiom A, etc.)
- 37D25** Nonuniformly hyperbolic systems (Lyapunov exponents, Pesin theory, etc.)
- 37D30** Partially hyperbolic systems and dominated splittings
- 37D35** Thermodynamic formalism, variational principles, equilibrium states for dynamical systems
- 37D40** Dynamical systems of geometric origin and hyperbolicity (geodesic and horocycle flows, etc.)
- 37D45** Strange attractors, chaotic dynamics of systems with hyperbolic behavior
- 37D99** None of the above, but in this section

## **37Exx Low-dimensional dynamical systems**

- 37E05** Dynamical systems involving maps of the interval (piecewise continuous, continuous, smooth)
- 37E10** Dynamical systems involving maps of the circle
- 37E15** Combinatorial dynamics (types of periodic orbits)
- 37E20** Universality and renormalization of dynamical systems [See also [37F25](#)]
- 37E25** Dynamical systems involving maps of trees and graphs
- 37E30** Dynamical systems involving homeomorphisms and diffeomorphisms of planes and surfaces
- 37E35** Flows on surfaces
- 37E40** Dynamical aspects of twist maps
- 37E45** Rotation numbers and vectors
- 37E99** None of the above, but in this section

## **37Fxx Dynamical systems over complex numbers [See also [30D05](#), [32H50](#)]**

- 37F05** Dynamical systems involving relations and correspondences in one complex variable
- 37F10** Dynamics of complex polynomials, rational maps, entire and meromorphic functions; Fatou and Julia sets [See also [32A10](#), [32A20](#), [32H02](#), [32H04](#)]
- 37F12** Critical orbits for holomorphic dynamical systems
- 37F15** Expanding holomorphic maps; hyperbolicity; structural stability of holomorphic dynamical systems
- 37F20** Combinatorics and topology in relation with holomorphic dynamical systems
- 37F25** Renormalization of holomorphic dynamical systems

- 37F30** Quasiconformal methods in holomorphic dynamics; quasiconformal dynamics
- 37F32** Fuchsian and Kleinian groups as dynamical systems
- 37F34** Teichmüller theory; moduli spaces of holomorphic dynamical systems
- 37F35** Conformal densities and Hausdorff dimension for holomorphic dynamical systems
- 37F40** Geometric limits in holomorphic dynamics
- 37F45** Holomorphic families of dynamical systems; holomorphic motions; semigroups of holomorphic maps
- 37F46** Bifurcations; parameter spaces in holomorphic dynamics; the Mandelbrot and Multibrot sets
- 37F50** Small divisors, rotation domains and linearization in holomorphic dynamics
- 37F75** Dynamical aspects of holomorphic foliations and vector fields [See also [32M25](#), [32S65](#), [34Mxx](#)]
- 37F80** Higher-dimensional holomorphic and meromorphic dynamics
- 37F99** None of the above, but in this section

## **37Gxx Local and nonlocal bifurcation theory for dynamical systems [See also [34C23](#), [34K18](#)]**

- 37G05** Normal forms for dynamical systems
- 37G10** Bifurcations of singular points in dynamical systems
- 37G15** Bifurcations of limit cycles and periodic orbits in dynamical systems
- 37G20** Hyperbolic singular points with homoclinic trajectories in dynamical systems
- 37G25** Bifurcations connected with nontransversal intersection in dynamical systems
- 37G30** Infinite nonwandering sets arising in bifurcations of dynamical systems
- 37G35** Dynamical aspects of attractors and their bifurcations
- 37G40** Dynamical aspects of symmetries, equivariant bifurcation theory
- 37G99** None of the above, but in this section

## **37Hxx Random dynamical systems [See also [15B52](#), [34D08](#), [34F05](#), [47B80](#), [70L05](#), [82C05](#), [93Exx](#)]**

- 37H05** General theory of random and stochastic dynamical systems
- 37H10** Generation, random and stochastic difference and differential equations [See also [34F05](#), [34K50](#), [60H10](#), [60H15](#)]
- 37H12** Random iteration

- 37H15** Random dynamical systems aspects of multiplicative ergodic theory, Lyapunov exponents [See also [34D08](#), [37Axx](#), [37Cxx](#), [37Dxx](#)]
- 37H20** Bifurcation theory for random and stochastic dynamical systems [See also [37Gxx](#)]
- 37H30** Stability theory for random and stochastic dynamical systems
- 37H99** None of the above, but in this section
- 37Jxx Dynamical aspects of finite-dimensional Hamiltonian and Lagrangian systems** [See also [53Dxx](#), [70Fxx](#), [70Hxx](#)]
- 37J05** General theory of finite-dimensional Hamiltonian and Lagrangian systems, Hamiltonian and Lagrangian structures, symmetries, invariants
- 37J10** Symplectic and canonical mappings
- 37J12** Fixed points and periodic points of finite-dimensional Hamiltonian and Lagrangian systems
- 37J20** Bifurcation problems for finite-dimensional Hamiltonian and Lagrangian systems
- 37J25** Stability problems for finite-dimensional Hamiltonian and Lagrangian systems
- 37J30** Obstructions to integrability for finite-dimensional Hamiltonian and Lagrangian systems (nonintegrability criteria)
- 37J35** Completely integrable finite-dimensional Hamiltonian systems, integration methods, integrability tests
- 37J37** Relations of finite-dimensional Hamiltonian and Lagrangian systems with Lie algebras and other algebraic structures
- 37J38** Relations of finite-dimensional Hamiltonian and Lagrangian systems with algebraic geometry, complex analysis, special functions
- 37J39** Relations of finite-dimensional Hamiltonian and Lagrangian systems with topology, geometry and differential geometry (symplectic geometry, Poisson geometry, etc.) [See also [53D20](#)]
- 37J40** Perturbations of finite-dimensional Hamiltonian systems, normal forms, small divisors, KAM theory, Arnol'd diffusion
- 37J45** Periodic, homoclinic and heteroclinic orbits of finite-dimensional Hamiltonian systems
- 37J50** Action-minimizing orbits and measures for finite-dimensional Hamiltonian and Lagrangian systems; variational principles; degree-theoretic methods
- 37J55** Contact systems [See also [53D10](#)]
- 37J60** Nonholonomic dynamical systems [See also [70F25](#)]
- 37J65** Nonautonomous Hamiltonian dynamical systems (Painlevé equations, etc.)
- 37J70** Completely integrable discrete dynamical systems
- 37J99** None of the above, but in this section
- 37Kxx Dynamical system aspects of infinite-dimensional Hamiltonian and Lagrangian systems** [See also [35Axx](#), [35Qxx](#)]
- 37K05** General theory of infinite-dimensional Hamiltonian and Lagrangian systems, Hamiltonian and Lagrangian structures, symmetries, conservation laws
- 37K10** Completely integrable infinite-dimensional Hamiltonian and Lagrangian systems, integration methods, integrability tests, integrable hierarchies (KdV, KP, Toda, etc.)
- 37K15** Inverse spectral and scattering methods for infinite-dimensional Hamiltonian and Lagrangian systems
- 37K20** Relations of infinite-dimensional Hamiltonian and Lagrangian dynamical systems with algebraic geometry, complex analysis, and special functions [See also [14H70](#)]
- 37K25** Relations of infinite-dimensional Hamiltonian and Lagrangian dynamical systems with topology, geometry and differential geometry
- 37K30** Relations of infinite-dimensional Hamiltonian and Lagrangian dynamical systems with infinite-dimensional Lie algebras and other algebraic structures
- 37K35** Lie-Bäcklund and other transformations for infinite-dimensional Hamiltonian and Lagrangian systems
- 37K40** Soliton theory, asymptotic behavior of solutions of infinite-dimensional Hamiltonian systems
- 37K45** Stability problems for infinite-dimensional Hamiltonian and Lagrangian systems
- 37K50** Bifurcation problems for infinite-dimensional Hamiltonian and Lagrangian systems
- 37K55** Perturbations, KAM for infinite-dimensional Hamiltonian and Lagrangian systems
- 37K58** Variational principles and methods for infinite-dimensional Hamiltonian and Lagrangian systems
- 37K60** Lattice dynamics; integrable lattice equations [See also [37L60](#)]
- 37K99** None of the above, but in this section
- 37Lxx Infinite-dimensional dissipative dynamical systems** [See also [35Bxx](#), [35Qxx](#)]
- 37L05** General theory of infinite-dimensional dissipative dynamical systems, nonlinear semigroups, evolution equations
- 37L10** Normal forms, center manifold theory, bifurcation theory for infinite-dimensional dissipative dynamical systems
- 37L15** Stability problems for infinite-dimensional dissipative dynamical systems
- 37L20** Symmetries of infinite-dimensional dissipative dynamical systems
- 37L25** Inertial manifolds and other invariant attracting sets of infinite-dimensional dissipative dynamical systems

- 37L30** Infinite-dimensional dissipative dynamical systems— attractors and their dimensions, Lyapunov exponents
- 37L40** Invariant measures for infinite-dimensional dissipative dynamical systems
- 37L45** Hyperbolicity; Lyapunov functions for infinite-dimensional dissipative dynamical systems
- 37L50** Noncompact semigroups; dispersive equations; perturbations of infinite-dimensional dissipative dynamical systems
- 37L55** Infinite-dimensional random dynamical systems; stochastic equations [See also [35R60](#), [60H10](#), [60H15](#)]
- 37L60** Lattice dynamics and infinite-dimensional dissipative dynamical systems [See also [37K60](#)]
- 37L65** Special approximation methods (nonlinear Galerkin, etc.) for infinite-dimensional dissipative dynamical systems
- 37L99** None of the above, but in this section
- 37Mxx Approximation methods and numerical treatment of dynamical systems {For numerical analysis, see also [65Pxx](#); for software etc., see [37-04](#)}**
- 37M05** Simulation of dynamical systems
- 37M10** Time series analysis of dynamical systems
- 37M15** Discretization methods and integrators (symplectic, variational, geometric, etc.) for dynamical systems
- 37M20** Computational methods for bifurcation problems in dynamical systems
- 37M21** Computational methods for invariant manifolds of dynamical systems
- 37M22** Computational methods for attractors of dynamical systems
- 37M25** Computational methods for ergodic theory (approximation of invariant measures, computation of Lyapunov exponents, entropy, etc.)
- 37M99** None of the above, but in this section
- 37Nxx Applications of dynamical systems**
- 37N05** Dynamical systems in classical and celestial mechanics [See mainly [70Fxx](#), [70Hxx](#), [70Kxx](#)]
- 37N10** Dynamical systems in fluid mechanics, oceanography and meteorology [See mainly [76-XX](#), especially [76D05](#), [76F20](#), [86A05](#), [86A10](#)]
- 37N15** Dynamical systems in solid mechanics [See mainly [74Hxx](#)]
- 37N20** Dynamical systems in other branches of physics (quantum mechanics, general relativity, laser physics)
- 37N25** Dynamical systems in biology [See also [92-XX](#)]
- 37N30** Dynamical systems in numerical analysis [See also [65-XX](#)]
- 37N35** Dynamical systems in control [See also [93-XX](#)]
- 37N40** Dynamical systems in optimization and economics [See also [90-XX](#), [91-XX](#)]
- 37N99** None of the above, but in this section
- 37Pxx Arithmetic and non-Archimedean dynamical systems [See also [11S82](#), [37A45](#)]**
- 37P05** Arithmetic and non-Archimedean dynamical systems involving polynomial and rational maps
- 37P10** Arithmetic and non-Archimedean dynamical systems involving analytic and meromorphic maps
- 37P15** Dynamical systems over global ground fields
- 37P20** Dynamical systems over non-Archimedean local ground fields
- 37P25** Dynamical systems over finite ground fields
- 37P30** Height functions; Green functions; invariant measures in arithmetic and non-Archimedean dynamical systems [See also [11G50](#), [14G40](#)]
- 37P35** Arithmetic properties of periodic points
- 37P40** Non-Archimedean Fatou and Julia sets
- 37P45** Families and moduli spaces in arithmetic and non-Archimedean dynamical systems
- 37P50** Dynamical systems on Berkovich spaces
- 37P55** Arithmetic dynamics on general algebraic varieties
- 37P99** None of the above, but in this section
- 39-XX Difference and functional equations**
- 39-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to difference and functional equations
- 39-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to difference and functional equations
- 39-02** Research exposition (monographs, survey articles) pertaining to difference and functional equations
- 39-03** History of difference and functional equations [Consider also classification numbers pertaining to Section [01](#)]
- 39-04** Software, source code, etc. for problems pertaining to difference and functional equations
- 39-06** Proceedings, conferences, collections, etc. pertaining to difference and functional equations
- 39-08** Computational methods for problems pertaining to difference and functional equations
- 39-11** Research data for problems pertaining to difference and functional equations

## **39Axx Difference equations {For dynamic equations on time scales, see 34N05; for dynamical systems, see 37-XX}**

- 39A05** General theory of difference equations
- 39A06** Linear difference equations
- 39A10** Additive difference equations
- 39A12** Discrete version of topics in analysis
- 39A13** Difference equations, scaling ( $q$ -differences) [See also 33Dxx]
- 39A14** Partial difference equations
- 39A20** Multiplicative and other generalized difference equations, e.g., of Lyness type
- 39A21** Oscillation theory for difference equations
- 39A22** Growth, boundedness, comparison of solutions to difference equations
- 39A23** Periodic solutions of difference equations
- 39A24** Almost periodic solutions of difference equations
- 39A26** Fuzzy difference equations
- 39A27** Boundary value problems for difference equations
- 39A28** Bifurcation theory for difference equations
- 39A30** Stability theory for difference equations
- 39A33** Chaotic behavior of solutions of difference equations
- 39A35** Integrable difference and lattice equations; integrability tests
- 39A45** Difference equations in the complex domain
- 39A50** Stochastic difference equations
- 39A60** Applications of difference equations
- 39A70** Difference operators [See also 47B39]
- 39A99** None of the above, but in this section

## **39Bxx Functional equations and inequalities [See also 30D05]**

- 39B05** General theory of functional equations and inequalities
- 39B12** Iteration theory, iterative and composite equations [See also 26A18, 30D05, 37-XX]
- 39B22** Functional equations for real functions [See also 26A51, 26B25]
- 39B32** Functional equations for complex functions [See also 30D05]
- 39B42** Matrix and operator functional equations [See also 47Jxx]
- 39B52** Functional equations for functions with more general domains and/or ranges
- 39B55** Orthogonal additivity and other conditional functional equations
- 39B62** Functional inequalities, including subadditivity, convexity, etc. [See also 26A51, 26B25, 26Dxx]

- 39B72** Systems of functional equations and inequalities
- 39B82** Stability, separation, extension, and related topics for functional equations [See also 46A22]
- 39B99** None of the above, but in this section

## **40-XX Sequences, series, summability**

- 40-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to sequences, series, summability
- 40-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to sequences, series, summability
- 40-02** Research exposition (monographs, survey articles) pertaining to sequences, series, summability
- 40-03** History of sequences, series, summability [Consider also classification numbers pertaining to Section 01]
- 40-04** Software, source code, etc. for problems pertaining to sequences, series, summability
- 40-06** Proceedings, conferences, collections, etc. pertaining to sequences, series, summability
- 40-08** Computational methods for problems pertaining to sequences, series, summability
- 40-11** Research data for problems pertaining to sequences, series, summability

## **40Axx Convergence and divergence of infinite limiting processes**

- 40A05** Convergence and divergence of series and sequences
- 40A10** Convergence and divergence of integrals
- 40A15** Convergence and divergence of continued fractions [See also 30B70]
- 40A20** Convergence and divergence of infinite products
- 40A25** Approximation to limiting values (summation of series, etc.) {For the Euler-Maclaurin summation formula, see 65B15}
- 40A30** Convergence and divergence of series and sequences of functions
- 40A35** Ideal and statistical convergence [See also 40G15]
- 40A99** None of the above, but in this section

## **40Bxx Multiple sequences and series**

- 40B05** Multiple sequences and series (should also be assigned at least one other classification number in this section)
- 40B99** None of the above, but in this section



## 40Cxx General summability methods

- 40C05 Matrix methods for summability
- 40C10 Integral methods for summability
- 40C15 Function-theoretic methods (including power series methods and semicontinuous methods) for summability
- 40C99 None of the above, but in this section

## 40Dxx Direct theorems on summability

- 40D05 General theorems on summability
- 40D09 Structure of summability fields
- 40D10 Tauberian constants and oscillation limits in summability theory
- 40D15 Convergence factors and summability factors
- 40D20 Summability and bounded fields of methods
- 40D25 Inclusion and equivalence theorems in summability theory
- 40D99 None of the above, but in this section

## 40Exx Inversion theorems

- 40E05 Tauberian theorems, general
- 40E10 Growth estimates
- 40E15 Lacunary inversion theorems
- 40E20 Tauberian constants
- 40E99 None of the above, but in this section

## 40Fxx Absolute and strong summability (should also be assigned at least one other classification number in Section 40)

- 40F05 Absolute and strong summability (should also be assigned at least one other classification number in Section 40)
- 40F99 None of the above, but in this section

## 40Gxx Special methods of summability

- 40G05 Cesàro, Euler, Nörlund and Hausdorff methods
- 40G10 Abel, Borel and power series methods
- 40G15 Summability methods using statistical convergence [See also 40A35]
- 40G99 None of the above, but in this section

## 40Hxx Functional analytic methods in summability

- 40H05 Functional analytic methods in summability
- 40H99 None of the above, but in this section

## 40Jxx Summability in abstract structures (should also be assigned at least one other classification number from Section 40) [See also 43A55, 46A35, 46B15]

- 40J05 Summability in abstract structures (should also be assigned at least one other classification number from Section 40) [See also 43A55, 46A35, 46B15]
- 40J99 None of the above, but in this section

## 41-XX Approximations and expansions {For approximation theory in the complex domain, see 30E05, 30E10; for trigonometric approximation and interpolation, see 42A10, 42A15; for numerical approximation, see 65Dxx}

- 41-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to approximations and expansions
- 41-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to approximations and expansions
- 41-02 Research exposition (monographs, survey articles) pertaining to approximations and expansions
- 41-03 History of approximations and expansions [Consider also classification numbers pertaining to Section 01]
- 41-04 Software, source code, etc. for problems pertaining to approximations and expansions
- 41-06 Proceedings, conferences, collections, etc. pertaining to approximations and expansions
- 41-11 Research data for problems pertaining to approximations and expansions

## 41Axx Approximations and expansions {For approximation theory in the complex domain, see 30E05, 30E10; for trigonometric approximation and interpolation, see 42A10, 42A15; for numerical approximation, see 65Dxx}

- 41A05 Interpolation in approximation theory [See also 42A15, 65D05]
- 41A10 Approximation by polynomials {For approximation by trigonometric polynomials, see 42A10}
- 41A15 Spline approximation
- 41A17 Inequalities in approximation (Bernstein, Jackson, Nikol'skiĭ-type inequalities)
- 41A20 Approximation by rational functions

- 41A21 Padé approximation
- 41A25 Rate of convergence, degree of approximation
- 41A27 Inverse theorems in approximation theory
- 41A28 Simultaneous approximation
- 41A29 Approximation with constraints
- 41A30 Approximation by other special function classes
- 41A35 Approximation by operators (in particular, by integral operators)
- 41A36 Approximation by positive operators
- 41A40 Saturation in approximation theory
- 41A44 Best constants in approximation theory
- 41A45 Approximation by arbitrary linear expressions
- 41A46 Approximation by arbitrary nonlinear expressions; widths and entropy
- 41A50 Best approximation, Chebyshev systems
- 41A52 Uniqueness of best approximation
- 41A55 Approximate quadratures
- 41A58 Series expansions (e.g., Taylor, Lidstone series, but not Fourier series)
- 41A60 Asymptotic approximations, asymptotic expansions (steepest descent, etc.) [See also 30E15]
- 41A63 Multidimensional problems (should also be assigned at least one other classification number from Section 41)
- 41A65 Abstract approximation theory (approximation in normed linear spaces and other abstract spaces)
- 41A80 Remainders in approximation formulas
- 41A81 Weighted approximation
- 41A99 None of the above, but in this section

## 42-XX Harmonic analysis on Euclidean spaces

- 42-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to harmonic analysis on Euclidean spaces
- 42-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to harmonic analysis on Euclidean spaces
- 42-02 Research exposition (monographs, survey articles) pertaining to harmonic analysis on Euclidean spaces
- 42-03 History of harmonic analysis on Euclidean spaces [Consider also classification numbers pertaining to Section 01]
- 42-04 Software, source code, etc. for problems pertaining to harmonic analysis on Euclidean spaces
- 42-06 Proceedings, conferences, collections, etc. pertaining to harmonic analysis on Euclidean spaces
- 42-08 Computational methods for problems pertaining to harmonic analysis on Euclidean spaces
- 42-11 Research data for problems pertaining to harmonic analysis on Euclidean spaces

## 42Axx Harmonic analysis in one variable

- 42A05 Trigonometric polynomials, inequalities, extremal problems
- 42A10 Trigonometric approximation
- 42A15 Trigonometric interpolation
- 42A16 Fourier coefficients, Fourier series of functions with special properties, special Fourier series {For automorphic theory, see mainly 11F30}
- 42A20 Convergence and absolute convergence of Fourier and trigonometric series
- 42A24 Summability and absolute summability of Fourier and trigonometric series
- 42A32 Trigonometric series of special types (positive coefficients, monotonic coefficients, etc.)
- 42A38 Fourier and Fourier-Stieltjes transforms and other transforms of Fourier type
- 42A45 Multipliers in one variable harmonic analysis
- 42A50 Conjugate functions, conjugate series, singular integrals
- 42A55 Lacunary series of trigonometric and other functions; Riesz products
- 42A61 Probabilistic methods for one variable harmonic analysis
- 42A63 Uniqueness of trigonometric expansions, uniqueness of Fourier expansions, Riemann theory, localization
- 42A65 Completeness of sets of functions in one variable harmonic analysis
- 42A70 Trigonometric moment problems in one variable harmonic analysis
- 42A75 Classical almost periodic functions, mean periodic functions [See also 43A60]
- 42A82 Positive definite functions in one variable harmonic analysis
- 42A85 Convolution, factorization for one variable harmonic analysis
- 42A99 None of the above, but in this section

## 42Bxx Harmonic analysis in several variables {For automorphic theory, see mainly 11F30}

- 42B05 Fourier series and coefficients in several variables
- 42B08 Summability in several variables
- 42B10 Fourier and Fourier-Stieltjes transforms and other transforms of Fourier type
- 42B15 Multipliers for harmonic analysis in several variables
- 42B20 Singular and oscillatory integrals (Calderón-Zygmund, etc.)
- 42B25 Maximal functions, Littlewood-Paley theory
- 42B30  $H^p$ -spaces
- 42B35 Function spaces arising in harmonic analysis
- 42B37 Harmonic analysis and PDEs [See also 35-XX]
- 42B99 None of the above, but in this section

## 42Cxx Nontrigonometric harmonic analysis

- 42C05 Orthogonal functions and polynomials, general theory of nontrigonometric harmonic analysis [See also 33C45, 33C50, 33D45]
- 42C10 Fourier series in special orthogonal functions (Legendre polynomials, Walsh functions, etc.)
- 42C15 General harmonic expansions, frames
- 42C20 Other transformations of harmonic type
- 42C25 Uniqueness and localization for orthogonal series
- 42C30 Completeness of sets of functions in nontrigonometric harmonic analysis
- 42C40 Nontrigonometric harmonic analysis involving wavelets and other special systems
- 42C99 None of the above, but in this section

## 43-XX Abstract harmonic analysis {For other analysis on topological and Lie groups, see 22Exx}

- 43-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to abstract harmonic analysis
- 43-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to abstract harmonic analysis
- 43-02 Research exposition (monographs, survey articles) pertaining to abstract harmonic analysis
- 43-03 History of abstract harmonic analysis [Consider also classification numbers pertaining to Section 01]
- 43-04 Software, source code, etc. for problems pertaining to abstract harmonic analysis
- 43-06 Proceedings, conferences, collections, etc. pertaining to abstract harmonic analysis
- 43-08 Computational methods for problems pertaining to abstract harmonic analysis
- 43-11 Research data for problems pertaining to abstract harmonic analysis

## 43Axx Abstract harmonic analysis {For other analysis on topological and Lie groups, see 22Exx}

- 43A05 Measures on groups and semigroups, etc.
- 43A07 Means on groups, semigroups, etc.; amenable groups
- 43A10 Measure algebras on groups, semigroups, etc.
- 43A15  $L^p$ -spaces and other function spaces on groups, semigroups, etc.
- 43A17 Analysis on ordered groups,  $H^p$ -theory
- 43A20  $L^1$ -algebras on groups, semigroups, etc.

- 43A22 Homomorphisms and multipliers of function spaces on groups, semigroups, etc.
- 43A25 Fourier and Fourier-Stieltjes transforms on locally compact and other abelian groups
- 43A30 Fourier and Fourier-Stieltjes transforms on non-abelian groups and on semigroups, etc.
- 43A32 Other transforms and operators of Fourier type
- 43A35 Positive definite functions on groups, semigroups, etc.
- 43A40 Character groups and dual objects
- 43A45 Spectral synthesis on groups, semigroups, etc.
- 43A46 Special sets (thin sets, Kronecker sets, Helson sets, Ditkin sets, Sidon sets, etc.)
- 43A50 Convergence of Fourier series and of inverse transforms
- 43A55 Summability methods on groups, semigroups, etc. [See also 40J05]
- 43A60 Almost periodic functions on groups and semigroups and their generalizations (recurrent functions, distal functions, etc.); almost automorphic functions
- 43A62 Harmonic analysis on hypergroups
- 43A65 Representations of groups, semigroups, etc. (aspects of abstract harmonic analysis) [See also 22A10, 22A20, 22Dxx, 22E45]
- 43A70 Analysis on specific locally compact and other abelian groups [See also 11R56, 22B05]
- 43A75 Harmonic analysis on specific compact groups
- 43A77 Harmonic analysis on general compact groups
- 43A80 Analysis on other specific Lie groups [See also 22Exx]
- 43A85 Harmonic analysis on homogeneous spaces
- 43A90 Harmonic analysis and spherical functions [See also 22E45, 22E46, 33C55]
- 43A95 Categorical methods for abstract harmonic analysis [See also 46Mxx]
- 43A99 None of the above, but in this section

## 44-XX Integral transforms, operational calculus {For fractional derivatives and integrals, see 26A33; for Fourier transforms, see 42A38, 42B10; for integral transforms in distribution spaces, see 46F12; for numerical methods, see 65R10}

- 44-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to integral transforms
- 44-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to integral transforms

- 44-02 Research exposition (monographs, survey articles) pertaining to integral transforms
- 44-03 History of integral transforms [Consider also classification numbers pertaining to Section 01]
- 44-04 Software, source code, etc. for problems pertaining to integral transforms
- 44-06 Proceedings, conferences, collections, etc. pertaining to integral transforms
- 44-11 Research data for problems pertaining to integral transforms

**44Axx Integral transforms, operational calculus {For fractional derivatives and integrals, see 26A33; for Fourier transforms, see 42A38, 42B10; for integral transforms in distribution spaces, see 46F12; for numerical methods, see 65R10}**

- 44A05 General integral transforms [See also 42A38]
- 44A10 Laplace transform
- 44A12 Radon transform [See also 92C55]
- 44A15 Special integral transforms (Legendre, Hilbert, etc.)
- 44A20 Integral transforms of special functions
- 44A30 Multiple integral transforms
- 44A35 Convolution as an integral transform
- 44A40 Calculus of Mikusiński and other operational calculi
- 44A45 Classical operational calculus
- 44A55 Discrete operational calculus
- 44A60 Moment problems {For trigonometric moment problems, see 42A70}
- 44A99 None of the above, but in this section

**45-XX Integral equations**

- 45-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to integral equations
- 45-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to integral equations
- 45-02 Research exposition (monographs, survey articles) pertaining to integral equations
- 45-03 History of integral equations [Consider also classification numbers pertaining to Section 01]
- 45-04 Software, source code, etc. for problems pertaining to integral equations
- 45-06 Proceedings, conferences, collections, etc. pertaining to integral equations
- 45-11 Research data for problems pertaining to integral equations

**45Axx Linear integral equations**

- 45A05 Linear integral equations
- 45A99 None of the above, but in this section

**45Bxx Fredholm integral equations**

- 45B05 Fredholm integral equations
- 45B99 None of the above, but in this section

**45Cxx Eigenvalue problems for integral equations [See also 34Lxx, 35Pxx, 45P05, 47A75]**

- 45C05 Eigenvalue problems for integral equations [See also 34Lxx, 35Pxx, 45P05, 47A75]
- 45C99 None of the above, but in this section

**45Dxx Volterra integral equations [See also 34A12]**

- 45D05 Volterra integral equations [See also 34A12]
- 45D99 None of the above, but in this section

**45Exx Singular integral equations [See also 30E20, 30E25, 44A15, 44A35]**

- 45E05 Integral equations with kernels of Cauchy type [See also 35J15]
- 45E10 Integral equations of the convolution type (Abel, Picard, Toeplitz and Wiener-Hopf type) [See also 47B35]
- 45E99 None of the above, but in this section

**45Fxx Systems of linear integral equations**

- 45F05 Systems of nonsingular linear integral equations
- 45F10 Dual, triple, etc., integral and series equations
- 45F15 Systems of singular linear integral equations
- 45F99 None of the above, but in this section

**45Gxx Nonlinear integral equations [See also 47H30, 47Jxx]**

- 45G05 Singular nonlinear integral equations
- 45G10 Other nonlinear integral equations
- 45G15 Systems of nonlinear integral equations
- 45G99 None of the above, but in this section

**45Hxx Integral equations with miscellaneous special kernels [See also 44A15]**

- 45H05 Integral equations with miscellaneous special kernels [See also 44A15]
- 45H99 None of the above, but in this section

**45Jxx** Integro-ordinary differential equations [See also [34K05](#), [34K30](#), [47G20](#)]

**45J05** Integro-ordinary differential equations [See also [34K05](#), [34K30](#), [47G20](#)]

**45J99** None of the above, but in this section

**45Kxx** Integro-partial differential equations [See also [34K30](#), [35R09](#), [35R10](#), [47G20](#)]

**45K05** Integro-partial differential equations [See also [34K30](#), [35R09](#), [35R10](#), [47G20](#)]

**45K99** None of the above, but in this section

**45Lxx** Theoretical approximation of solutions to integral equations {For numerical analysis, see [65Rxx](#)}

**45L05** Theoretical approximation of solutions to integral equations {For numerical analysis, see [65Rxx](#)}

**45L99** None of the above, but in this section

**45Mxx** Qualitative behavior of solutions to integral equations

**45M05** Asymptotics of solutions to integral equations

**45M10** Stability theory for integral equations

**45M15** Periodic solutions of integral equations

**45M20** Positive solutions of integral equations

**45M99** None of the above, but in this section

**45Nxx** Abstract integral equations, integral equations in abstract spaces

**45N05** Abstract integral equations, integral equations in abstract spaces

**45N99** None of the above, but in this section

**45Pxx** Integral operators [See also [47B38](#), [47G10](#)]

**45P05** Integral operators [See also [47B38](#), [47G10](#)]

**45P99** None of the above, but in this section

**45Qxx** Inverse problems for integral equations

**45Q05** Inverse problems for integral equations

**45Q99** None of the above, but in this section

**45Rxx** Random integral equations [See also [60H20](#)]

**45R05** Random integral equations [See also [60H20](#)]

**45R99** None of the above, but in this section

**46-XX** Functional analysis {For manifolds modeled on topological linear spaces, see [57Nxx](#), [58Bxx](#)}

**46-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to functional analysis

**46-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to functional analysis

**46-02** Research exposition (monographs, survey articles) pertaining to functional analysis

**46-03** History of functional analysis [Consider also classification numbers pertaining to Section [01](#)]

**46-04** Software, source code, etc. for problems pertaining to functional analysis

**46-06** Proceedings, conferences, collections, etc. pertaining to functional analysis

**46-08** Computational methods for problems pertaining to functional analysis

**46-11** Research data for problems pertaining to functional analysis

**46Axx** Topological linear spaces and related structures {For function spaces, see [46Exx](#)}

**46A03** General theory of locally convex spaces

**46A04** Locally convex Fréchet spaces and (DF)-spaces

**46A08** Barrelled spaces, bornological spaces

**46A11** Spaces determined by compactness or summability properties (nuclear spaces, Schwartz spaces, Montel spaces, etc.)

**46A13** Spaces defined by inductive or projective limits (LB, LF, etc.) [See also [46M40](#)]

**46A16** Not locally convex spaces (metrizable topological linear spaces, locally bounded spaces, quasi-Banach spaces, etc.)

**46A17** Bornologies and related structures; Mackey convergence, etc.

**46A19** Other “topological” linear spaces (convergence spaces, ranked spaces, spaces with a metric taking values in an ordered structure more general than  $\mathbb{R}$ , etc.)

**46A20** Duality theory for topological vector spaces

**46A22** Theorems of Hahn-Banach type; extension and lifting of functionals and operators [See also [46M10](#)]

**46A25** Reflexivity and semi-reflexivity [See also [46B10](#)]

**46A30** Open mapping and closed graph theorems; completeness (including  $B$ -,  $B_r$ -completeness)



- 46A32** Spaces of linear operators; topological tensor products; approximation properties [See also [46B28](#), [46M05](#), [47L05](#), [47L20](#)]
- 46A35** Summability and bases in topological vector spaces [See also [46B15](#)]
- 46A40** Ordered topological linear spaces, vector lattices [See also [06F20](#), [46B40](#), [46B42](#)]
- 46A45** Sequence spaces (including Köthe sequence spaces) [See also [46B45](#)]
- 46A50** Compactness in topological linear spaces; angelic spaces, etc.
- 46A55** Convex sets in topological linear spaces; Choquet theory [See also [52A07](#)]
- 46A61** Graded Fréchet spaces and tame operators
- 46A63** Topological invariants ((DN),  $(\Omega)$ , etc.) for locally convex spaces
- 46A70** Saks spaces and their duals (strict topologies, mixed topologies, two-norm spaces, co-Saks spaces, etc.)
- 46A80** Modular spaces
- 46A99** None of the above, but in this section
- 46Bxx Normed linear spaces and Banach spaces; Banach lattices {For function spaces, see [46Exx](#)}**
- 46B03** Isomorphic theory (including renorming) of Banach spaces
- 46B04** Isometric theory of Banach spaces
- 46B06** Asymptotic theory of Banach spaces [See also [52A23](#)]
- 46B07** Local theory of Banach spaces
- 46B08** Ultraproduct techniques in Banach space theory [See also [46M07](#)]
- 46B09** Probabilistic methods in Banach space theory [See also [60Bxx](#)]
- 46B10** Duality and reflexivity in normed linear and Banach spaces [See also [46A25](#)]
- 46B15** Summability and bases; functional analytic aspects of frames in Banach and Hilbert spaces [See also [46A35](#), [42C15](#)]
- 46B20** Geometry and structure of normed linear spaces
- 46B22** Radon-Nikodým, Kreĭn-Milman and related properties [See also [46G10](#)]
- 46B25** Classical Banach spaces in the general theory
- 46B26** Nonseparable Banach spaces
- 46B28** Spaces of operators; tensor products; approximation properties [See also [46A32](#), [46M05](#), [47L05](#), [47L20](#)]
- 46B40** Ordered normed spaces [See also [46A40](#), [46B42](#)]
- 46B42** Banach lattices [See also [46A40](#), [46B40](#)]
- 46B45** Banach sequence spaces [See also [46A45](#)]
- 46B50** Compactness in Banach (or normed) spaces
- 46B70** Interpolation between normed linear spaces [See also [46M35](#)]
- 46B80** Nonlinear classification of Banach spaces; nonlinear quotients
- 46B85** Embeddings of discrete metric spaces into Banach spaces; applications in topology and computer science [See also [05C12](#), [68Rxx](#)]
- 46B87** Lineability in functional analysis [See also [15A03](#)]
- 46B99** None of the above, but in this section
- 46Cxx Inner product spaces and their generalizations, Hilbert spaces {For function spaces, see [46Exx](#)}**
- 46C05** Hilbert and pre-Hilbert spaces: geometry and topology (including spaces with semidefinite inner product)
- 46C07** Hilbert subspaces (= operator ranges); complementation (Aronszajn, de Branges, etc.) [See also [46B70](#), [46M35](#)]
- 46C15** Characterizations of Hilbert spaces
- 46C20** Spaces with indefinite inner product (Kreĭn spaces, Pontryagin spaces, etc.) [See also [47B50](#)]
- 46C50** Generalizations of inner products (semi-inner products, partial inner products, etc.)
- 46C99** None of the above, but in this section
- 46Exx Linear function spaces and their duals [See also [30H05](#), [32A38](#), [46F05](#)] {For function algebras, see [46J10](#)}**
- 46E05** Lattices of continuous, differentiable or analytic functions
- 46E10** Topological linear spaces of continuous, differentiable or analytic functions
- 46E15** Banach spaces of continuous, differentiable or analytic functions
- 46E20** Hilbert spaces of continuous, differentiable or analytic functions
- 46E22** Hilbert spaces with reproducing kernels (= (proper) functional Hilbert spaces, including de Branges-Rovnyak and other structured spaces) [See also [47B32](#)]
- 46E25** Rings and algebras of continuous, differentiable or analytic functions {For Banach function algebras, see [46J10](#), [46J15](#)}
- 46E27** Spaces of measures [See also [28A33](#), [46Gxx](#)]
- 46E30** Spaces of measurable functions ( $L^p$ -spaces, Orlicz spaces, Köthe function spaces, Lorentz spaces, rearrangement invariant spaces, ideal spaces, etc.)
- 46E35** Sobolev spaces and other spaces of “smooth” functions, embedding theorems, trace theorems
- 46E36** Sobolev (and similar kinds of) spaces of functions on metric spaces; analysis on metric spaces

- 46E39** Sobolev (and similar kinds of) spaces of functions of discrete variables
- 46E40** Spaces of vector- and operator-valued functions
- 46E50** Spaces of differentiable or holomorphic functions on infinite-dimensional spaces [See also [46G20](#), [46G25](#), [47H60](#)]
- 46E99** None of the above, but in this section
- 46Fxx Distributions, generalized functions, distribution spaces** [See also [46T30](#)]
- 46F05** Topological linear spaces of test functions, distributions and ultradistributions [See also [46E10](#), [46E35](#)]
- 46F10** Operations with distributions and generalized functions
- 46F12** Integral transforms in distribution spaces [See also [42-XX](#), [44-XX](#)]
- 46F15** Hyperfunctions, analytic functionals [See also [32A25](#), [32A45](#), [32C35](#), [58J15](#)]
- 46F20** Distributions and ultradistributions as boundary values of analytic functions [See also [30D40](#), [30E25](#), [32A40](#)]
- 46F25** Distributions on infinite-dimensional spaces [See also [58C35](#)]
- 46F30** Generalized functions for nonlinear analysis (Rosinger, Colombeau, nonstandard, etc.)
- 46F99** None of the above, but in this section
- 46Gxx Measures, integration, derivative, holomorphy (all involving infinite-dimensional spaces)** [See also [28-XX](#), [46Txx](#)]
- 46G05** Derivatives of functions in infinite-dimensional spaces [See also [46T20](#), [58C20](#), [58C25](#)]
- 46G10** Vector-valued measures and integration [See also [28Bxx](#), [46B22](#)]
- 46G12** Measures and integration on abstract linear spaces [See also [28C20](#), [46T12](#)]
- 46G15** Functional analytic lifting theory [See also [28A51](#)]
- 46G20** Infinite-dimensional holomorphy [See also [32-XX](#), [46E50](#), [46T25](#), [58B12](#), [58C10](#)]
- 46G25** (Spaces of) multilinear mappings, polynomials [See also [46E50](#), [46G20](#), [47H60](#)]
- 46G99** None of the above, but in this section
- 46Hxx Topological algebras, normed rings and algebras, Banach algebras {For group algebras, convolution algebras and measure algebras, see [43A10](#), [43A20](#)}**
- 46H05** General theory of topological algebras
- 46H10** Ideals and subalgebras
- 46H15** Representations of topological algebras
- 46H20** Structure, classification of topological algebras
- 46H25** Normed modules and Banach modules, topological modules (if not placed in [13-XX](#) or [16-XX](#))
- 46H30** Functional calculus in topological algebras [See also [47A60](#)]
- 46H35** Topological algebras of operators [See mainly [47Lxx](#)]
- 46H40** Automatic continuity
- 46H70** Nonassociative topological algebras [See also [46K70](#), [46L70](#)]
- 46H99** None of the above, but in this section
- 46Jxx Commutative Banach algebras and commutative topological algebras** [See also [46E25](#)]
- 46J05** General theory of commutative topological algebras
- 46J10** Banach algebras of continuous functions, function algebras [See also [46E25](#)]
- 46J15** Banach algebras of differentiable or analytic functions,  $H^p$ -spaces [See also [30H10](#), [32A35](#), [32A37](#), [32A38](#), [42B30](#)]
- 46J20** Ideals, maximal ideals, boundaries
- 46J25** Representations of commutative topological algebras
- 46J30** Subalgebras of commutative topological algebras
- 46J40** Structure and classification of commutative topological algebras
- 46J45** Radical Banach algebras
- 46J99** None of the above, but in this section
- 46Kxx Topological (rings and) algebras with an involution** [See also [16W10](#)]
- 46K05** General theory of topological algebras with involution
- 46K10** Representations of topological algebras with involution
- 46K15** Hilbert algebras
- 46K50** Nonselfadjoint (sub)algebras in algebras with involution
- 46K70** Nonassociative topological algebras with an involution [See also [46H70](#), [46L70](#)]
- 46K99** None of the above, but in this section

- 46Lxx Selfadjoint operator algebras ( $C^*$ -algebras, von Neumann ( $W^*$ -) algebras, etc.)** [See also [22D25](#), [47Lxx](#)]
- 46L05** General theory of  $C^*$ -algebras
- 46L06** Tensor products of  $C^*$ -algebras
- 46L07** Operator spaces and completely bounded maps [See also [47L25](#)]
- 46L08**  $C^*$ -modules
- 46L09** Free products of  $C^*$ -algebras
- 46L10** General theory of von Neumann algebras
- 46L30** States of selfadjoint operator algebras
- 46L35** Classifications of  $C^*$ -algebras
- 46L36** Classification of factors
- 46L37** Subfactors and their classification
- 46L40** Automorphisms of selfadjoint operator algebras
- 46L45** Decomposition theory for  $C^*$ -algebras
- 46L51** Noncommutative measure and integration
- 46L52** Noncommutative function spaces
- 46L53** Noncommutative probability and statistics
- 46L54** Free probability and free operator algebras
- 46L55** Noncommutative dynamical systems [See also [28Dxx](#), [37Kxx](#), [37Lxx](#), [37A55](#)]
- 46L57** Derivations, dissipations and positive semigroups in  $C^*$ -algebras
- 46L60** Applications of selfadjoint operator algebras to physics [See also [46N50](#), [46N55](#), [47L90](#), [81T05](#), [82B10](#), [82C10](#)]
- 46L65** Quantizations, deformations for selfadjoint operator algebras
- 46L67** Quantum groups (operator algebraic aspects)
- 46L70** Nonassociative selfadjoint operator algebras [See also [46H70](#), [46K70](#)]
- 46L80**  $K$ -theory and operator algebras (including cyclic theory) [See also [18F25](#), [19Kxx](#), [46M20](#), [55Rxx](#), [58J22](#)]
- 46L85** Noncommutative topology [See also [58B32](#), [58B34](#), [58J22](#)]
- 46L87** Noncommutative differential geometry [See also [58B32](#), [58B34](#), [58J22](#)]
- 46L89** Other “noncommutative” mathematics based on  $C^*$ -algebra theory [See also [58B32](#), [58B34](#), [58J22](#)]
- 46L99** None of the above, but in this section
- 46Mxx Methods of category theory in functional analysis** [See also [18-XX](#)]
- 46M05** Tensor products in functional analysis [See also [46A32](#), [46B28](#), [47A80](#)]
- 46M07** Ultraproducts in functional analysis [See also [46B08](#), [46S20](#)]
- 46M10** Projective and injective objects in functional analysis [See also [46A22](#)]
- 46M15** Categories, functors in functional analysis {For  $K$ -theory, Ext, etc., see [19K33](#), [46L80](#), [46M18](#), [46M20](#)}
- 46M18** Homological methods in functional analysis (exact sequences, right inverses, lifting, etc.)
- 46M20** Methods of algebraic topology in functional analysis (cohomology, sheaf and bundle theory, etc.) [See also [14F06](#), [18Fxx](#), [19Kxx](#), [32Cxx](#), [32Lxx](#), [46L80](#), [46M15](#), [46M18](#), [55Rxx](#)]
- 46M35** Abstract interpolation of topological vector spaces [See also [46B70](#)]
- 46M40** Inductive and projective limits in functional analysis [See also [46A13](#)]
- 46M99** None of the above, but in this section
- 46Nxx Miscellaneous applications of functional analysis** [See also [47Nxx](#)]
- 46N10** Applications of functional analysis in optimization, convex analysis, mathematical programming, economics
- 46N20** Applications of functional analysis to differential and integral equations
- 46N30** Applications of functional analysis in probability theory and statistics
- 46N40** Applications of functional analysis in numerical analysis [See also [65Jxx](#)]
- 46N50** Applications of functional analysis in quantum physics
- 46N55** Applications of functional analysis in statistical physics
- 46N60** Applications of functional analysis in biology and other sciences
- 46N99** None of the above, but in this section
- 46Sxx Other (nonclassical) types of functional analysis** [See also [47Sxx](#)]
- 46S05** Quaternionic functional analysis
- 46S10** Functional analysis over fields other than  $\mathbb{R}$  or  $\mathbb{C}$  or the quaternions; non-Archimedean functional analysis [See also [12J25](#), [32P05](#)]
- 46S20** Nonstandard functional analysis [See also [03H05](#)]
- 46S30** Constructive functional analysis [See also [03F60](#)]
- 46S40** Fuzzy functional analysis [See also [03E72](#)]
- 46S50** Functional analysis in probabilistic metric linear spaces
- 46S60** Functional analysis on superspaces (supermanifolds) or graded spaces [See also [58A50](#), [58C50](#)]
- 46S99** None of the above, but in this section

## **46Txx Nonlinear functional analysis** [See also [47Hxx](#), [47Jxx](#), [58Cxx](#), [58Dxx](#)]

- 46T05** Infinite-dimensional manifolds [See also [53Axx](#), [57N20](#), [58Bxx](#), [58Dxx](#)]
- 46T10** Manifolds of mappings
- 46T12** Measure (Gaussian, cylindrical, etc.) and integrals (Feynman, path, Fresnel, etc.) on manifolds [See also [28Cxx](#), [46G12](#), [60-XX](#)]
- 46T20** Continuous and differentiable maps in nonlinear functional analysis [See also [46G05](#)]
- 46T25** Holomorphic maps in nonlinear functional analysis [See also [46G20](#)]
- 46T30** Distributions and generalized functions on nonlinear spaces [See also [46Fxx](#)]
- 46T99** None of the above, but in this section

## **47-XX Operator theory**

- 47-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to operator theory
- 47-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to operator theory
- 47-02** Research exposition (monographs, survey articles) pertaining to operator theory
- 47-03** History of operator theory [Consider also classification numbers pertaining to [Section 01](#)]
- 47-04** Software, source code, etc. for problems pertaining to operator theory
- 47-06** Proceedings, conferences, collections, etc. pertaining to operator theory
- 47-08** Computational methods for problems pertaining to operator theory
- 47-11** Research data for problems pertaining to operator theory

## **47Axx General theory of linear operators**

- 47A05** General (adjoints, conjugates, products, inverses, domains, ranges, etc.)
- 47A06** Linear relations (multivalued linear operators)
- 47A07** Forms (bilinear, sesquilinear, multilinear)
- 47A08** Operator matrices [See also [47A13](#)]
- 47A10** Spectrum, resolvent
- 47A11** Local spectral properties of linear operators
- 47A12** Numerical range, numerical radius
- 47A13** Several-variable operator theory (spectral, Fredholm, etc.)
- 47A15** Invariant subspaces of linear operators [See also [47A46](#)]
- 47A16** Cyclic vectors, hypercyclic and chaotic operators

- 47A20** Dilations, extensions, compressions of linear operators
- 47A25** Spectral sets of linear operators
- 47A30** Norms (inequalities, more than one norm, etc.) of linear operators
- 47A35** Ergodic theory of linear operators [See also [28Dxx](#), [37Axx](#)]
- 47A40** Scattering theory of linear operators [See also [34L25](#), [35P25](#), [37K15](#), [58J50](#), [81Uxx](#)]
- 47A45** Canonical models for contractions and nonselfadjoint linear operators
- 47A46** Chains (nests) of projections or of invariant subspaces, integrals along chains, etc.
- 47A48** Operator colligations (= nodes), vessels, linear systems, characteristic functions, realizations, etc.
- 47A50** Equations and inequalities involving linear operators, with vector unknowns
- 47A52** Linear operators and ill-posed problems, regularization [See also [35R25](#), [47J06](#), [65F22](#), [65J20](#), [65L08](#), [65M30](#), [65R30](#)]
- 47A53** (Semi-) Fredholm operators; index theories [See also [58B15](#), [58J20](#)]
- 47A55** Perturbation theory of linear operators [See also [47H14](#), [58J37](#), [70H09](#), [81Q15](#)]
- 47A56** Functions whose values are linear operators (operator- and matrix-valued functions, etc., including analytic and meromorphic ones)
- 47A57** Linear operator methods in interpolation, moment and extension problems [See also [30E05](#), [42A70](#), [42A82](#), [44A60](#)]
- 47A58** Linear operator approximation theory
- 47A60** Functional calculus for linear operators
- 47A62** Equations involving linear operators, with operator unknowns
- 47A63** Linear operator inequalities
- 47A64** Operator means involving linear operators, shorted linear operators, etc.
- 47A65** Structure theory of linear operators
- 47A66** Quasitriangular and nonquasitriangular, quasideagonal and nonquasideagonal linear operators
- 47A67** Representation theory of linear operators
- 47A68** Factorization theory (including Wiener-Hopf and spectral factorizations) of linear operators
- 47A70** (Generalized) eigenfunction expansions of linear operators; rigged Hilbert spaces
- 47A75** Eigenvalue problems for linear operators [See also [47J10](#), [49R05](#)]
- 47A80** Tensor products of linear operators [See also [46M05](#)]
- 47A99** None of the above, but in this section

## 47Bxx Special classes of linear operators

- 47B01 Operators on Banach spaces
- 47B02 Operators on Hilbert spaces (general)
- 47B06 Riesz operators; eigenvalue distributions; approximation numbers,  $s$ -numbers, Kolmogorov numbers, entropy numbers, etc. of operators
- 47B07 Linear operators defined by compactness properties
- 47B10 Linear operators belonging to operator ideals (nuclear,  $p$ -summing, in the Schatten-von Neumann classes, etc.) [See also 47L20]
- 47B12 Sectorial operators
- 47B13 Cowen-Douglas operators
- 47B15 Hermitian and normal operators (spectral measures, functional calculus, etc.)
- 47B20 Subnormal operators, hyponormal operators, etc.
- 47B25 Linear symmetric and selfadjoint operators (unbounded)
- 47B28 Nonselfadjoint operators [See also 47A45, 81Q12]
- 47B32 Linear operators in reproducing-kernel Hilbert spaces (including de Branges, de Branges-Rovnyak, and other structured spaces) [See also 46E22]
- 47B33 Linear composition operators
- 47B34 Kernel operators
- 47B35 Toeplitz operators, Hankel operators, Wiener-Hopf operators {For other integral operators, see also 45P05, 47G10} [See also 32A25, 32M15]
- 47B36 Jacobi (tridiagonal) operators (matrices) and generalizations
- 47B37 Linear operators on special spaces (weighted shifts, operators on sequence spaces, etc.)
- 47B38 Linear operators on function spaces (general)
- 47B39 Linear difference operators [See also 39A70]
- 47B40 Spectral operators, decomposable operators, well-bounded operators, etc.
- 47B44 Linear accretive operators, dissipative operators, etc.
- 47B47 Commutators, derivations, elementary operators, etc.
- 47B48 Linear operators on Banach algebras
- 47B49 Transformers, preservers (linear operators on spaces of linear operators)
- 47B50 Linear operators on spaces with an indefinite metric [See also 46C20]
- 47B60 Linear operators on ordered spaces
- 47B65 Positive linear operators and order-bounded operators
- 47B80 Random linear operators [See also 47H40, 60H25]
- 47B90 Operator theory and harmonic analysis [See also 42-XX, 43-XX, 44-XX]
- 47B91 Operators on complex function spaces
- 47B92 Operators on real function spaces
- 47B93 Operators arising in mathematical physics
- 47B99 None of the above, but in this section

## 47Cxx Individual linear operators as elements of algebraic systems

- 47C05 Linear operators in algebras
- 47C10 Linear operators in  $*$ -algebras
- 47C15 Linear operators in  $C^*$ - or von Neumann algebras
- 47C99 None of the above, but in this section

## 47Dxx Groups and semigroups of linear operators, their generalizations and applications

- 47D03 Groups and semigroups of linear operators [See also 20M20] {For nonlinear operators, see 47H20}
- 47D06 One-parameter semigroups and linear evolution equations [See also 34G10, 34K30]
- 47D07 Markov semigroups and applications to diffusion processes {For Markov processes, see 60Jxx}
- 47D08 Schrödinger and Feynman-Kac semigroups
- 47D09 Operator sine and cosine functions and higher-order Cauchy problems [See also 34G10]
- 47D60  $C$ -semigroups, regularized semigroups
- 47D62 Integrated semigroups
- 47D99 None of the above, but in this section

## 47Exx Ordinary differential operators [See also 34Bxx, 34Lxx]

- 47E05 Ordinary differential operators (should also be assigned at least one other classification number in Section 47) [See also 34Bxx, 34Lxx]
- 47E07 Functional-differential and differential-difference operators [See also 34K08]
- 47E99 None of the above, but in this section

## 47Fxx Partial differential operators [See also 35Pxx, 58Jxx]

- 47F05 Partial differential operators (should also be assigned at least one other classification number in Section 47) [See also 35Pxx, 58Jxx]
- 47F10 Elliptic operators and their generalizations {For elliptic complexes, see 58J10}
- 47F99 None of the above, but in this section



**47Gxx Integral, integro-differential, and pseudodifferential operators [See also 58Jxx]**

- 47G10 Integral operators [See also 45P05]
- 47G20 Integro-differential operators [See also 34K30, 35R09, 35R10, 45Jxx, 45Kxx]
- 47G30 Pseudodifferential operators [See also 35Sxx, 58Jxx]
- 47G40 Potential operators [See also 31-XX]
- 47G99 None of the above, but in this section

**47Hxx Nonlinear operators and their properties {For global and geometric aspects, see 49J53, 58-XX, especially 58Cxx}**

- 47H04 Set-valued operators [See also 28B20, 54C60, 58C06]
- 47H05 Monotone operators and generalizations
- 47H06 Nonlinear accretive operators, dissipative operators, etc.
- 47H07 Monotone and positive operators on ordered Banach spaces or other ordered topological vector spaces
- 47H08 Measures of noncompactness and condensing mappings,  $K$ -set contractions, etc.
- 47H09 Contraction-type mappings, nonexpansive mappings,  $A$ -proper mappings, etc.
- 47H10 Fixed-point theorems [See also 37C25, 54H25, 55M20, 58C30]
- 47H11 Degree theory for nonlinear operators [See also 55M25, 58C30]
- 47H14 Perturbations of nonlinear operators [See also 47A55, 58J37, 70H09, 70K60, 81Q15]
- 47H20 Semigroups of nonlinear operators [See also 37L05, 47J35, 54H15, 58D07]
- 47H25 Nonlinear ergodic theorems [See also 28Dxx, 37Axx, 47A35]
- 47H30 Particular nonlinear operators (superposition, Hammerstein, Nemytskii, Uryson, etc.) [See also 45Gxx, 45P05]
- 47H40 Random nonlinear operators [See also 47B80, 60H25]
- 47H60 Multilinear and polynomial operators [See also 46G25]
- 47H99 None of the above, but in this section

**47Jxx Equations and inequalities involving nonlinear operators [See also 46Txx] {For global and geometric aspects, see 58-XX}**

- 47J05 Equations involving nonlinear operators (general) [See also 47H10, 47J25]
- 47J06 Nonlinear ill-posed problems [See also 35R25, 47A52, 65F22, 65J20, 65L08, 65M30, 65R30]

- 47J07 Abstract inverse mapping and implicit function theorems involving nonlinear operators [See also 46T20, 58C15]
- 47J10 Nonlinear spectral theory, nonlinear eigenvalue problems [See also 49R05]
- 47J15 Abstract bifurcation theory involving nonlinear operators [See also 34C23, 37Gxx, 58E07, 58E09]
- 47J20 Variational and other types of inequalities involving nonlinear operators (general) [See also 49J40]
- 47J22 Variational and other types of inclusions [See also 34A60, 49J21, 49K21]
- 47J25 Iterative procedures involving nonlinear operators [See also 47J26, 65J15]
- 47J26 Fixed-point iterations [See also 47J25]
- 47J30 Variational methods involving nonlinear operators [See also 58Exx]
- 47J35 Nonlinear evolution equations [See also 34G20, 35K90, 35L90, 35Qxx, 35R20, 37Kxx, 37Lxx, 47H20, 58D25]
- 47J40 Equations with nonlinear hysteresis operators [See also 34C55, 74N30]
- 47J99 None of the above, but in this section

**47Lxx Linear spaces and algebras of operators [See also 46Lxx]**

- 47L05 Linear spaces of operators [See also 46A32, 46B28]
- 47L07 Convex sets and cones of operators [See also 46A55]
- 47L10 Algebras of operators on Banach spaces and other topological linear spaces
- 47L15 Operator algebras with symbol structure
- 47L20 Operator ideals [See also 47B10]
- 47L22 Ideals of polynomials and of multilinear mappings in operator theory
- 47L25 Operator spaces (= matricially normed spaces) [See also 46L07]
- 47L30 Abstract operator algebras on Hilbert spaces
- 47L35 Nest algebras, CSL algebras
- 47L40 Limit algebras, subalgebras of  $C^*$ -algebras
- 47L45 Dual algebras; weakly closed singly generated operator algebras
- 47L50 Dual spaces of operator algebras
- 47L55 Representations of (nonselfadjoint) operator algebras
- 47L60 Algebras of unbounded operators; partial algebras of operators
- 47L65 Crossed product algebras (analytic crossed products)
- 47L70 Nonassociative nonselfadjoint operator algebras
- 47L75 Other nonselfadjoint operator algebras
- 47L80 Algebras of specific types of operators (Toeplitz, integral, pseudodifferential, etc.)
- 47L90 Applications of operator algebras to the sciences
- 47L99 None of the above, but in this section

## **47Nxx Miscellaneous applications of operator theory [See also 46Nxx]**

- 47N10 Applications of operator theory in optimization, convex analysis, mathematical programming, economics
- 47N20 Applications of operator theory to differential and integral equations
- 47N30 Applications of operator theory in probability theory and statistics
- 47N40 Applications of operator theory in numerical analysis [See also 65Jxx]
- 47N50 Applications of operator theory in the physical sciences
- 47N60 Applications of operator theory in chemistry and life sciences
- 47N70 Applications of operator theory in systems, signals, circuits, and control theory
- 47N99 None of the above, but in this section

## **47Sxx Other (nonclassical) types of operator theory [See also 46Sxx]**

- 47S05 Quaternionic operator theory
- 47S10 Operator theory over fields other than  $\mathbb{R}$ ,  $\mathbb{C}$  or the quaternions; non-Archimedean operator theory
- 47S20 Nonstandard operator theory [See also 03H05]
- 47S30 Constructive operator theory [See also 03F60]
- 47S40 Fuzzy operator theory [See also 03E72]
- 47S50 Operator theory in probabilistic metric linear spaces [See also 54E70]
- 47S99 None of the above, but in this section

## **49-XX Calculus of variations and optimal control; optimization [See also 34H05, 34K35, 65Kxx, 90Cxx, 93-XX]**

- 49-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to calculus of variations and optimal control
- 49-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to calculus of variations and optimal control
- 49-02 Research exposition (monographs, survey articles) pertaining to calculus of variations and optimal control
- 49-03 History of calculus of variations and optimal control [Consider also classification numbers pertaining to Section 01]
- 49-04 Software, source code, etc. for problems pertaining to calculus of variations and optimal control

- 49-06 Proceedings, conferences, collections, etc. pertaining to calculus of variations and optimal control
- 49-11 Research data for problems pertaining to calculus of variations and optimal control

## **49Jxx Existence theories in calculus of variations and optimal control**

- 49J05 Existence theories for free problems in one independent variable
- 49J10 Existence theories for free problems in two or more independent variables
- 49J15 Existence theories for optimal control problems involving ordinary differential equations
- 49J20 Existence theories for optimal control problems involving partial differential equations
- 49J21 Existence theories for optimal control problems involving relations other than differential equations
- 49J27 Existence theories for problems in abstract spaces [See also 90C48, 93C25]
- 49J30 Existence of optimal solutions belonging to restricted classes (Lipschitz controls, bang-bang controls, etc.)
- 49J35 Existence of solutions for minimax problems
- 49J40 Variational inequalities [See also 47J20]
- 49J45 Methods involving semicontinuity and convergence; relaxation
- 49J50 Fréchet and Gateaux differentiability in optimization [See also 46G05, 58C20]
- 49J52 Nonsmooth analysis [See also 46G05, 58C50, 90C56]
- 49J53 Set-valued and variational analysis [See also 28B20, 47H04, 54C60, 58C06]
- 49J55 Existence of optimal solutions to problems involving randomness [See also 93E20]
- 49J99 None of the above, but in this section

## **49Kxx Optimality conditions**

- 49K05 Optimality conditions for free problems in one independent variable
- 49K10 Optimality conditions for free problems in two or more independent variables
- 49K15 Optimality conditions for problems involving ordinary differential equations
- 49K20 Optimality conditions for problems involving partial differential equations
- 49K21 Optimality conditions for problems involving relations other than differential equations
- 49K27 Optimality conditions for problems in abstract spaces [See also 90C48, 93C25]
- 49K30 Optimality conditions for solutions belonging to restricted classes (Lipschitz controls, bang-bang controls, etc.)

- 49K35** Optimality conditions for minimax problems
- 49K40** Sensitivity, stability, well-posedness [See also [90C31](#)]
- 49K45** Optimality conditions for problems involving randomness [See also [93E20](#)]
- 49K99** None of the above, but in this section
- 49Lxx Hamilton-Jacobi theories** [See also [70H20](#), [35F21](#)]
- 49L05** Hamilton-Jacobi equations in optimal control and differential games
- 49L20** Dynamic programming in optimal control and differential games
- 49L25** Viscosity solutions to Hamilton-Jacobi equations in optimal control and differential games
- 49L99** None of the above, but in this section
- 49Mxx Numerical methods in optimal control** [See also [65Kxx](#), [90-08](#), [90Cxx](#)]
- 49M05** Numerical methods based on necessary conditions
- 49M15** Newton-type methods [See also [90C53](#)]
- 49M20** Numerical methods of relaxation type
- 49M25** Discrete approximations in optimal control
- 49M27** Decomposition methods
- 49M29** Numerical methods involving duality
- 49M37** Numerical methods based on nonlinear programming [See also [65Kxx](#), [90C30](#)]
- 49M40** PDE constrained optimization
- 49M99** None of the above, but in this section
- 49Nxx Miscellaneous topics in calculus of variations and optimal control**
- 49N05** Linear optimal control problems [See also [93C05](#)]
- 49N10** Linear-quadratic optimal control problems
- 49N15** Duality theory (optimization) [See also [90C46](#)]
- 49N20** Periodic optimal control problems
- 49N25** Impulsive optimal control problems
- 49N30** Problems with incomplete information (optimization) [See also [93C41](#)]
- 49N35** Optimal feedback synthesis [See also [93B52](#)]
- 49N45** Inverse problems in optimal control
- 49N60** Regularity of solutions in optimal control
- 49N70** Differential games and control [See also [91A23](#)]
- 49N75** Pursuit and evasion games [See also [91A24](#)]
- 49N80** Mean field games and control [See also [91A16](#)]
- 49N90** Applications of optimal control and differential games [See also [90C90](#), [91A80](#), [93C95](#)]
- 49N99** None of the above, but in this section
- 49Qxx Manifolds and measure-geometric topics** [See also [58Exx](#)]
- 49Q05** Minimal surfaces and optimization [See also [53A10](#), [58E12](#)]
- 49Q10** Optimization of shapes other than minimal surfaces [See also [90C90](#)]
- 49Q12** Sensitivity analysis for optimization problems on manifolds
- 49Q15** Geometric measure and integration theory, integral and normal currents in optimization [See also [28A75](#), [32C30](#), [58A25](#), [58C35](#)]
- 49Q20** Variational problems in a geometric measure-theoretic setting
- 49Q25** Optimal transportation [See also [90B06](#)]
- 49Q99** None of the above, but in this section
- 49Rxx Variational methods for eigenvalues of operators (should also be assigned at least one other classification number in Section 49)** [See also [47A75](#)]
- 49R05** Variational methods for eigenvalues of operators (should also be assigned at least one other classification number in Section 49) [See also [47A75](#)]
- 49R99** None of the above, but in this section
- 49Sxx Variational principles of physics (should also be assigned at least one other classification number in Section 49)**
- 49S05** Variational principles of physics (should also be assigned at least one other classification number in Section 49)
- 49S99** None of the above, but in this section
- 51-XX Geometry {For algebraic geometry, see [14-XX](#); for differential geometry, see [53-XX](#)}**
- 51-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to geometry
- 51-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to geometry
- 51-02** Research exposition (monographs, survey articles) pertaining to geometry
- 51-03** History of geometry [Consider also classification numbers pertaining to Section 01]
- 51-04** Software, source code, etc. for problems pertaining to geometry
- 51-06** Proceedings, conferences, collections, etc. pertaining to geometry

**51-08** Computational methods for problems pertaining to geometry

**51-11** Research data for problems pertaining to geometry

## **51Axx Linear incidence geometry**

**51A05** General theory of linear incidence geometry and projective geometries

**51A10** Homomorphism, automorphism and dualities in linear incidence geometry

**51A15** Linear incidence geometric structures with parallelism

**51A20** Configuration theorems in linear incidence geometry

**51A25** Algebraization in linear incidence geometry [See also [12Kxx](#), [20N05](#)]

**51A30** Desarguesian and Pappian geometries

**51A35** Non-Desarguesian affine and projective planes

**51A40** Translation planes and spreads in linear incidence geometry

**51A45** Incidence structures embeddable into projective geometries

**51A50** Polar geometry, symplectic spaces, orthogonal spaces

**51A99** None of the above, but in this section

## **51Bxx Nonlinear incidence geometry**

**51B05** General theory of nonlinear incidence geometry

**51B10** Möbius geometries

**51B15** Laguerre geometries

**51B20** Minkowski geometries in nonlinear incidence geometry

**51B25** Lie geometries in nonlinear incidence geometry

**51B99** None of the above, but in this section

## **51Cxx Ring geometry (Hjelmslev, Barbilian, etc.)**

**51C05** Ring geometry (Hjelmslev, Barbilian, etc.)

**51C99** None of the above, but in this section

## **51Dxx Geometric closure systems**

**51D05** Abstract (Maeda) geometries

**51D10** Abstract geometries with exchange axiom

**51D15** Abstract geometries with parallelism

**51D20** Combinatorial geometries and geometric closure systems [See also [05B25](#), [05B35](#)]

**51D25** Lattices of subspaces and geometric closure systems [See also [05B35](#)]

**51D30** Continuous geometries, geometric closure systems and related topics [See also [06Cxx](#)]

**51D99** None of the above, but in this section

## **51Exx Finite geometry and special incidence structures**

**51E05** General block designs in finite geometry [See also [05B05](#)]

**51E10** Steiner systems in finite geometry [See also [05B05](#)]

**51E12** Generalized quadrangles and generalized polygons in finite geometry

**51E14** Finite partial geometries (general), nets, partial spreads

**51E15** Finite affine and projective planes (geometric aspects)

**51E20** Combinatorial structures in finite projective spaces [See also [05Bxx](#)]

**51E21** Blocking sets, ovals,  $k$ -arcs

**51E22** Linear codes and caps in Galois spaces [See also [94B05](#)]

**51E23** Spreads and packing problems in finite geometry

**51E24** Buildings and the geometry of diagrams

**51E25** Other finite nonlinear geometries

**51E26** Other finite linear geometries

**51E30** Other finite incidence structures (geometric aspects) [See also [05B30](#)]

**51E99** None of the above, but in this section

## **51Fxx Metric geometry**

**51F05** Absolute planes in metric geometry

**51F10** Absolute spaces in metric geometry

**51F15** Reflection groups, reflection geometries [See also [20H10](#), [20H15](#)] {For Coxeter groups, see [20F55](#)}

**51F20** Congruence and orthogonality in metric geometry [See also [20H05](#)]

**51F25** Orthogonal and unitary groups in metric geometry [See also [20H05](#)]

**51F30** Lipschitz and coarse geometry of metric spaces [See also [53C23](#)]

**51F99** None of the above, but in this section

## **51Gxx Ordered geometries (ordered incidence structures, etc.)**

**51G05** Ordered geometries (ordered incidence structures, etc.)

**51G99** None of the above, but in this section

## 51Hxx Topological geometry

- 51H05 General theory of topological geometry
- 51H10 Topological linear incidence structures
- 51H15 Topological nonlinear incidence structures
- 51H20 Topological geometries on manifolds [See also 57-XX]
- 51H25 Geometries with differentiable structure [See also 53Cxx, especially 53C70]
- 51H30 Geometries with algebraic manifold structure [See also 14-XX]
- 51H99 None of the above, but in this section

## 51Jxx Incidence groups

- 51J05 General theory of incidence groups
- 51J10 Projective incidence groups
- 51J15 Kinematic spaces
- 51J20 Representation by near-fields and near-algebras [See also 12K05, 16Y30]
- 51J99 None of the above, but in this section

## 51Kxx Distance geometry

- 51K05 General theory of distance geometry
- 51K10 Synthetic differential geometry
- 51K99 None of the above, but in this section

## 51Lxx Geometric order structures [See also 53C75]

- 51L05 Geometry of orders of nondifferentiable curves
- 51L10 Directly differentiable curves in geometric order structures
- 51L15  $n$ -vertex theorems via direct methods
- 51L20 Geometry of orders of surfaces
- 51L99 None of the above, but in this section

## 51Mxx Real and complex geometry

- 51M04 Elementary problems in Euclidean geometries
- 51M05 Euclidean geometries (general) and generalizations
- 51M09 Elementary problems in hyperbolic and elliptic geometries
- 51M10 Hyperbolic and elliptic geometries (general) and generalizations
- 51M15 Geometric constructions in real or complex geometry
- 51M16 Inequalities and extremum problems in real or complex geometry {For convex problems, see 52A40}
- 51M20 Polyhedra and polytopes; regular figures, division of spaces [See also 51F15]
- 51M25 Length, area and volume in real or complex geometry [See also 26B15]

51M30 Line geometries and their generalizations [See also 53A25]

51M35 Synthetic treatment of fundamental manifolds in projective geometries (Grassmannians, Veronesians and their generalizations) [See also 14M15]

51M99 None of the above, but in this section

## 51Nxx Analytic and descriptive geometry

- 51N05 Descriptive geometry [See also 65D17, 68U07]
- 51N10 Affine analytic geometry
- 51N15 Projective analytic geometry
- 51N20 Euclidean analytic geometry
- 51N25 Analytic geometry with other transformation groups
- 51N30 Geometry of classical groups [See also 14L35, 20Gxx]
- 51N35 Questions of classical algebraic geometry [See also 14Nxx]
- 51N99 None of the above, but in this section

## 51Pxx Classical or axiomatic geometry and physics (should also be assigned at least one other classification number from Sections 70–86)

- 51P05 Classical or axiomatic geometry and physics (should also be assigned at least one other classification number from Sections 70–86)
- 51P99 None of the above, but in this section

## 52-XX Convex and discrete geometry

- 52-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to convex and discrete geometry
- 52-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to convex and discrete geometry
- 52-02 Research exposition (monographs, survey articles) pertaining to convex and discrete geometry
- 52-03 History of convex and discrete geometry [Consider also classification numbers pertaining to Section 01]
- 52-04 Software, source code, etc. for problems pertaining to convex and discrete geometry
- 52-06 Proceedings, conferences, collections, etc. pertaining to convex and discrete geometry
- 52-08 Computational methods for problems pertaining to convex and discrete geometry
- 52-11 Research data for problems pertaining to convex and discrete geometry



## 52Axx General convexity

- 52A01 Axiomatic and generalized convexity
- 52A05 Convex sets without dimension restrictions (aspects of convex geometry)
- 52A07 Convex sets in topological vector spaces (aspects of convex geometry) [See also 46A55]
- 52A10 Convex sets in 2 dimensions (including convex curves) [See also 53A04]
- 52A15 Convex sets in 3 dimensions (including convex surfaces) [See also 53A05, 53C45]
- 52A20 Convex sets in  $n$  dimensions (including convex hypersurfaces) [See also 53A07, 53C45]
- 52A21 Convexity and finite-dimensional Banach spaces (including special norms, zonoids, etc.) (aspects of convex geometry) [See also 46Bxx]
- 52A22 Random convex sets and integral geometry (aspects of convex geometry) [See also 53C65, 60D05]
- 52A23 Asymptotic theory of convex bodies [See also 46B06]
- 52A27 Approximation by convex sets
- 52A30 Variants of convex sets (star-shaped,  $(m, n)$ -convex, etc.)
- 52A35 Helly-type theorems and geometric transversal theory
- 52A37 Other problems of combinatorial convexity
- 52A38 Length, area, volume and convex sets (aspects of convex geometry) [See also 26B15, 28A75, 49Q20]
- 52A39 Mixed volumes and related topics in convex geometry
- 52A40 Inequalities and extremum problems involving convexity in convex geometry
- 52A41 Convex functions and convex programs in convex geometry [See also 26B25, 90C25]
- 52A55 Spherical and hyperbolic convexity
- 52A99 None of the above, but in this section

## 52Bxx Polytopes and polyhedra

- 52B05 Combinatorial properties of polytopes and polyhedra (number of faces, shortest paths, etc.) [See also 05Cxx]
- 52B10 Three-dimensional polytopes
- 52B11  $n$ -dimensional polytopes
- 52B12 Special polytopes (linear programming, centrally symmetric, etc.)
- 52B15 Symmetry properties of polytopes
- 52B20 Lattice polytopes in convex geometry (including relations with commutative algebra and algebraic geometry) [See also 06A11, 13F20, 13F55, 13Hxx, 52C05, 52C07]
- 52B22 Shellability for polytopes and polyhedra
- 52B35 Gale and other diagrams

- 52B40 Matroids in convex geometry (realizations in the context of convex polytopes, convexity in combinatorial structures, etc.) [See also 05B35, 52Cxx]
- 52B45 Dissections and valuations (Hilbert's third problem, etc.)
- 52B55 Computational aspects related to convexity {For computational methods, see 52-08; for computational geometry and algorithms, see 68Q25, 68U05; for numerical algorithms, see 65Yxx} [See also 68Uxx]
- 52B60 Isoperimetric problems for polytopes
- 52B70 Polyhedral manifolds
- 52B99 None of the above, but in this section

## 52Cxx Discrete geometry

- 52C05 Lattices and convex bodies in 2 dimensions (aspects of discrete geometry) [See also 11H06, 11H31, 11P21]
- 52C07 Lattices and convex bodies in  $n$  dimensions (aspects of discrete geometry) [See also 11H06, 11H31, 11P21]
- 52C10 Erdős problems and related topics of discrete geometry [See also 11Hxx]
- 52C15 Packing and covering in 2 dimensions (aspects of discrete geometry) [See also 05B40, 11H31]
- 52C17 Packing and covering in  $n$  dimensions (aspects of discrete geometry) [See also 05B40, 11H31]
- 52C20 Tilings in 2 dimensions (aspects of discrete geometry) [See also 05B45, 51M20]
- 52C22 Tilings in  $n$  dimensions (aspects of discrete geometry) [See also 05B45, 51M20]
- 52C23 Quasicrystals and aperiodic tilings in discrete geometry
- 52C25 Rigidity and flexibility of structures (aspects of discrete geometry) [See also 70B15]
- 52C26 Circle packings and discrete conformal geometry
- 52C30 Planar arrangements of lines and pseudolines (aspects of discrete geometry)
- 52C35 Arrangements of points, flats, hyperplanes (aspects of discrete geometry) [See also 14N20, 32S22]
- 52C40 Oriented matroids in discrete geometry
- 52C45 Combinatorial complexity of geometric structures [See also 68U05]
- 52C99 None of the above, but in this section

## 53-XX Differential geometry {For differential topology, see 57Rxx; for foundational questions of differentiable manifolds, see 58Axx}

- 53-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to differential geometry
- 53-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to differential geometry

- 53-02** Research exposition (monographs, survey articles) pertaining to differential geometry
- 53-03** History of differential geometry [Consider also classification numbers pertaining to Section [01](#)]
- 53-04** Software, source code, etc. for problems pertaining to differential geometry
- 53-06** Proceedings, conferences, collections, etc. pertaining to differential geometry
- 53-08** Computational methods for problems pertaining to differential geometry
- 53-11** Research data for problems pertaining to differential geometry

## **53Axx Classical differential geometry**

- 53A04** Curves in Euclidean and related spaces
- 53A05** Surfaces in Euclidean and related spaces
- 53A07** Higher-dimensional and  $n$ -codimensional surfaces in Euclidean and related  $n$ -spaces
- 53A10** Minimal surfaces in differential geometry, surfaces with prescribed mean curvature [See also [49Q05](#), [49Q10](#), [53C42](#)]
- 53A15** Affine differential geometry
- 53A17** Differential geometric aspects in kinematics
- 53A20** Projective differential geometry
- 53A25** Differential line geometry
- 53A30** Differential geometry of submanifolds of Möbius space
- 53A35** Non-Euclidean differential geometry
- 53A40** Other special differential geometries
- 53A45** Differential geometric aspects in vector and tensor analysis
- 53A55** Differential invariants (local theory), geometric objects
- 53A60** Differential geometry of webs [See also [14C21](#), [20N05](#)]
- 53A70** Discrete differential geometry
- 53A99** None of the above, but in this section

## **53Bxx Local differential geometry**

- 53B05** Linear and affine connections
- 53B10** Projective connections
- 53B12** Differential geometric aspects of statistical manifolds and information geometry
- 53B15** Other connections
- 53B20** Local Riemannian geometry
- 53B21** Methods of local Riemannian geometry
- 53B25** Local submanifolds [See also [53C40](#)]
- 53B30** Local differential geometry of Lorentz metrics, indefinite metrics

- 53B35** Local differential geometry of Hermitian and Kählerian structures [See also [32Qxx](#)]
- 53B40** Local differential geometry of Finsler spaces and generalizations (areal metrics)
- 53B50** Applications of local differential geometry to the sciences
- 53B99** None of the above, but in this section

## **53Cxx Global differential geometry [See also [51H25](#), [58-XX](#)] {For related bundle theory, see [55Rxx](#), [57Rxx](#)}**

- 53C05** Connections, general theory
- 53C07** Special connections and metrics on vector bundles (Hermitic-Einstein, Yang-Mills) [See also [32Q20](#)]
- 53C08** Differential geometric aspects of gerbes and differential characters
- 53C10**  $G$ -structures
- 53C12** Foliations (differential geometric aspects) [See also [57R30](#), [57R32](#)]
- 53C15** General geometric structures on manifolds (almost complex, almost product structures, etc.)
- 53C17** Sub-Riemannian geometry
- 53C18** Conformal structures on manifolds
- 53C20** Global Riemannian geometry, including pinching [See also [31C12](#), [58B20](#)]
- 53C21** Methods of global Riemannian geometry, including PDE methods; curvature restrictions [See also [58J60](#)]
- 53C22** Geodesics in global differential geometry [See also [58E10](#)]
- 53C23** Global geometric and topological methods (à la Gromov); differential geometric analysis on metric spaces
- 53C24** Rigidity results
- 53C25** Special Riemannian manifolds (Einstein, Sasakian, etc.)
- 53C26** Hyper-Kähler and quaternionic Kähler geometry, “special” geometry
- 53C27** Spin and  $\text{Spin}^c$  geometry
- 53C28** Twistor methods in differential geometry [See also [32L25](#)]
- 53C29** Issues of holonomy in differential geometry
- 53C30** Differential geometry of homogeneous manifolds [See also [14M15](#), [14M17](#), [32M10](#), [57T15](#)]
- 53C35** Differential geometry of symmetric spaces [See also [32M15](#), [57T15](#)]
- 53C38** Calibrations and calibrated geometries
- 53C40** Global submanifolds [See also [53B25](#)]
- 53C42** Differential geometry of immersions (minimal, prescribed curvature, tight, etc.) [See also [49Q05](#), [49Q10](#), [53A10](#), [57R40](#), [57R42](#)]
- 53C43** Differential geometric aspects of harmonic maps [See also [58E20](#)]

- 53C45** Global surface theory (convex surfaces à la A. D. Aleksandrov)
- 53C50** Global differential geometry of Lorentz manifolds, manifolds with indefinite metrics
- 53C55** Global differential geometry of Hermitian and Kählerian manifolds [See also [32Qxx](#)]
- 53C56** Other complex differential geometry [See also [32Qxx](#)]
- 53C60** Global differential geometry of Finsler spaces and generalizations (areal metrics) [See also [58B20](#)]
- 53C65** Integral geometry [See also [52A22](#), [60D05](#)]; differential forms, currents, etc. [See mainly [58Axx](#)]
- 53C70** Direct methods ( $G$ -spaces of Busemann, etc.)
- 53C75** Geometric orders, order geometry [See also [51Lxx](#)]
- 53C80** Applications of global differential geometry to the sciences
- 53C99** None of the above, but in this section

### **53Dxx Symplectic geometry, contact geometry** [See also [37Jxx](#), [70Gxx](#), [70Hxx](#)]

- 53D05** Symplectic manifolds, general
- 53D10** Contact manifolds, general
- 53D12** Lagrangian submanifolds; Maslov index
- 53D15** Almost contact and almost symplectic manifolds
- 53D17** Poisson manifolds; Poisson groupoids and algebroids
- 53D18** Generalized geometries (à la Hitchin)
- 53D20** Momentum maps; symplectic reduction
- 53D22** Canonical transformations in symplectic and contact geometry
- 53D25** Geodesic flows in symplectic geometry and contact geometry
- 53D30** Symplectic structures of moduli spaces
- 53D35** Global theory of symplectic and contact manifolds [See also [57Rxx](#)]
- 53D37** Symplectic aspects of mirror symmetry, homological mirror symmetry, and Fukaya category [See also [14J33](#)]
- 53D40** Symplectic aspects of Floer homology and cohomology
- 53D42** Symplectic field theory; contact homology
- 53D45** Gromov-Witten invariants, quantum cohomology, Frobenius manifolds [See also [14N35](#)]
- 53D50** Geometric quantization
- 53D55** Deformation quantization, star products
- 53D99** None of the above, but in this section

### **53Exx Geometric evolution equations**

- 53E10** Flows related to mean curvature
- 53E20** Ricci flows
- 53E30** Flows related to complex manifolds (e.g., Kähler-Ricci flows, Chern-Ricci flows)
- 53E40** Higher-order geometric flows
- 53E50** Flows related to symplectic and contact structures
- 53E99** None of the above, but in this section

### **53Zxx Applications of differential geometry to sciences and engineering**

- 53Z05** Applications of differential geometry to physics
- 53Z10** Applications of differential geometry to biology
- 53Z15** Applications of differential geometry to chemistry
- 53Z30** Applications of differential geometry to engineering
- 53Z50** Applications of differential geometry to data and computer science
- 53Z99** None of the above, but in this section

### **54-XX General topology {For the topology of manifolds of all dimensions, see [57Nxx](#)}**

- 54-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to general topology
- 54-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to general topology
- 54-02** Research exposition (monographs, survey articles) pertaining to general topology
- 54-03** History of general topology [Consider also classification numbers pertaining to Section [01](#)]
- 54-04** Software, source code, etc. for problems pertaining to general topology
- 54-06** Proceedings, conferences, collections, etc. pertaining to general topology
- 54-08** Computational methods for problems pertaining to general topology
- 54-11** Research data for problems pertaining to general topology

### **54Axx Generalities in topology**

- 54A05** Topological spaces and generalizations (closure spaces, etc.)
- 54A10** Several topologies on one set (change of topology, comparison of topologies, lattices of topologies)
- 54A15** Syntopogeneous structures
- 54A20** Convergence in general topology (sequences, filters, limits, convergence spaces, nets, etc.)

**54A25** Cardinality properties (cardinal functions and inequalities, discrete subsets) [See also [03Exx](#)] {For ultrafilters, see [54D80](#)}

**54A35** Consistency and independence results in general topology [See also [03E35](#)]

**54A40** Fuzzy topology [See also [03E72](#)]

**54A99** None of the above, but in this section

## **54Bxx Basic constructions in general topology**

**54B05** Subspaces in general topology

**54B10** Product spaces in general topology

**54B15** Quotient spaces, decompositions in general topology

**54B17** Adjunction spaces and similar constructions in general topology

**54B20** Hyperspaces in general topology

**54B30** Categorical methods in general topology [See also [18F60](#)]

**54B35** Spectra in general topology

**54B40** Presheaves and sheaves in general topology [See also [18F20](#)]

**54B99** None of the above, but in this section

## **54Cxx Maps and general types of topological spaces defined by maps**

**54C05** Continuous maps

**54C08** Weak and generalized continuity

**54C10** Special maps on topological spaces (open, closed, perfect, etc.)

**54C15** Retraction

**54C20** Extension of maps

**54C25** Embedding

**54C30** Real-valued functions in general topology [See also [26-XX](#)]

**54C35** Function spaces in general topology [See also [46Exx](#), [58D15](#)]

**54C40** Algebraic properties of function spaces in general topology [See also [46J10](#)]

**54C45**  $C$ - and  $C^*$ -embedding

**54C50** Topology of special sets defined by functions [See also [26A21](#)]

**54C55** Absolute neighborhood extensor, absolute extensor, absolute neighborhood retract (ANR), absolute retract spaces (general properties) [See also [55M15](#)]

**54C56** Shape theory in general topology [See also [55P55](#), [57N25](#)]

**54C60** Set-valued maps in general topology [See also [26E25](#), [28B20](#), [47H04](#), [58C06](#)]

**54C65** Selections in general topology [See also [28B20](#)]

**54C70** Entropy in general topology

**54C99** None of the above, but in this section

## **54Dxx Fairly general properties of topological spaces**

**54D05** Connected and locally connected spaces (general aspects)

**54D10** Lower separation axioms ( $T_0$ – $T_3$ , etc.)

**54D15** Higher separation axioms (completely regular, normal, perfectly or collectionwise normal, etc.)

**54D20** Noncompact covering properties (paracompact, Lindelöf, etc.)

**54D25** “ $P$ -minimal” and “ $P$ -closed” spaces

**54D30** Compactness

**54D35** Extensions of spaces (compactifications, supercompactifications, completions, etc.)

**54D40** Remainders in general topology

**54D45** Local compactness,  $\sigma$ -compactness

**54D50**  $k$ -spaces

**54D55** Sequential spaces

**54D60** Realcompactness and realcompactification

**54D65** Separability of topological spaces

**54D70** Base properties of topological spaces

**54D80** Special constructions of topological spaces (spaces of ultrafilters, etc.)

**54D99** None of the above, but in this section

## **54Exx Topological spaces with richer structures**

**54E05** Proximity structures and generalizations

**54E15** Uniform structures and generalizations

**54E17** Nearness spaces

**54E18**  $p$ -spaces,  $M$ -spaces,  $\sigma$ -spaces, etc.

**54E20** Stratifiable spaces, cosmic spaces, etc.

**54E25** Semimetric spaces

**54E30** Moore spaces

**54E35** Metric spaces, metrizability

**54E40** Special maps on metric spaces

**54E45** Compact (locally compact) metric spaces

**54E50** Complete metric spaces

**54E52** Baire category, Baire spaces

**54E55** Bitopologies

**54E70** Probabilistic metric spaces

**54E99** None of the above, but in this section

## 54Fxx Special properties of topological spaces

- 54F05 Linearly ordered topological spaces, generalized ordered spaces, and partially ordered spaces [See also [06B30](#), [06F30](#)]
- 54F15 Continua and generalizations
- 54F16 Hyperspaces of continua
- 54F17 Inverse limits of set-valued functions
- 54F35 Higher-dimensional local connectedness [See also [55Mxx](#), [55Nxx](#)]
- 54F45 Dimension theory in general topology [See also [55M10](#)]
- 54F50 Topological spaces of dimension  $\leq 1$ ; curves, dendrites [See also [26A03](#)]
- 54F55 Unicoherence, multicoherence
- 54F65 Topological characterizations of particular spaces
- 54F99 None of the above, but in this section

## 54Gxx Peculiar topological spaces

- 54G05 Extremely disconnected spaces,  $F$ -spaces, etc.
- 54G10  $P$ -spaces
- 54G12 Scattered spaces
- 54G15 Pathological topological spaces
- 54G20 Counterexamples in general topology
- 54G99 None of the above, but in this section

## 54Hxx Connections of general topology with other structures, applications

- 54H05 Descriptive set theory (topological aspects of Borel, analytic, projective, etc. sets) [See also [03E15](#), [26A21](#), [28A05](#)]
- 54H10 Topological representations of algebraic systems [See also [22-XX](#)]
- 54H11 Topological groups (topological aspects) [See also [22A05](#)]
- 54H12 Topological lattices, etc. (topological aspects) [See also [06B30](#), [06F30](#)]
- 54H13 Topological fields, rings, etc. (topological aspects) [See also [12Jxx](#)] {For algebraic aspects, see [13Jxx](#), [16W80](#)}
- 54H15 Transformation groups and semigroups (topological aspects) [See also [20M20](#), [22-XX](#), [57Sxx](#)]
- 54H25 Fixed-point and coincidence theorems (topological aspects) [See also [47H10](#), [55M20](#)]
- 54H30 Applications of general topology to computer science (e.g., digital topology, image processing) [See also [68U03](#)]
- 54H99 None of the above, but in this section

## 54Jxx Nonstandard topology [See also [03H05](#)]

- 54J05 Nonstandard topology [See also [03H05](#)]
- 54J99 None of the above, but in this section

## 55-XX Algebraic topology

- 55-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to algebraic topology
- 55-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to algebraic topology
- 55-02 Research exposition (monographs, survey articles) pertaining to algebraic topology
- 55-03 History of algebraic topology [Consider also classification numbers pertaining to [Section 01](#)]
- 55-04 Software, source code, etc. for problems pertaining to algebraic topology
- 55-06 Proceedings, conferences, collections, etc. pertaining to algebraic topology
- 55-08 Computational methods for problems pertaining to algebraic topology
- 55-11 Research data for problems pertaining to algebraic topology

## 55Mxx Classical topics in algebraic topology {For the topology of Euclidean spaces and manifolds, see [57Nxx](#)}

- 55M05 Duality in algebraic topology
- 55M10 Dimension theory in algebraic topology [See also [54F45](#)]
- 55M15 Absolute neighborhood retracts [See also [54C55](#)]
- 55M20 Fixed points and coincidences in algebraic topology [See also [54H25](#)]
- 55M25 Degree, winding number
- 55M30 Lyusternik-Shnirel'man category of a space, topological complexity à la Farber, topological robotics (topological aspects)
- 55M35 Finite groups of transformations in algebraic topology (including Smith theory) [See also [57S17](#)]
- 55M99 None of the above, but in this section



## 55Nxx Homology and cohomology theories in algebraic topology [See also 57Txx]

- 55N05 Čech types
- 55N07 Steenrod-Sitnikov homologies
- 55N10 Singular homology and cohomology theory
- 55N15 Topological  $K$ -theory [See also 19Lxx] {For algebraic  $K$ -theory, see 18F25, 19-XX}
- 55N20 Generalized (extraordinary) homology and cohomology theories in algebraic topology
- 55N22 Bordism and cobordism theories and formal group laws in algebraic topology [See also 14L05, 19L41, 57R75, 57R77, 57R85, 57R90]
- 55N25 Homology with local coefficients, equivariant cohomology
- 55N30 Sheaf cohomology in algebraic topology [See also 18F20, 32C35, 32L10]
- 55N31 Persistent homology and applications, topological data analysis [See also 62R40, 68T09]
- 55N32 Orbifold cohomology
- 55N33 Intersection homology and cohomology in algebraic topology
- 55N34 Elliptic cohomology
- 55N35 Other homology theories in algebraic topology
- 55N40 Axioms for homology theory and uniqueness theorems in algebraic topology
- 55N45 Products and intersections in homology and cohomology
- 55N91 Equivariant homology and cohomology in algebraic topology [See also 19L47]
- 55N99 None of the above, but in this section

## 55Pxx Homotopy theory {For simple homotopy type, see 57Q10}

- 55P05 Homotopy extension properties, cofibrations in algebraic topology
- 55P10 Homotopy equivalences in algebraic topology
- 55P15 Classification of homotopy type
- 55P20 Eilenberg-Mac Lane spaces
- 55P25 Spanier-Whitehead duality
- 55P30 Eckmann-Hilton duality
- 55P35 Loop spaces
- 55P40 Suspensions
- 55P42 Stable homotopy theory, spectra
- 55P43 Spectra with additional structure ( $E_\infty$ ,  $A_\infty$ , ring spectra, etc.)
- 55P45  $H$ -spaces and duals
- 55P47 Infinite loop spaces

- 55P48 Loop space machines and operads in algebraic topology [See also 18Mxx]
- 55P50 String topology
- 55P55 Shape theory [See also 54C56, 55Q07]
- 55P57 Proper homotopy theory
- 55P60 Localization and completion in homotopy theory
- 55P62 Rational homotopy theory
- 55P65 Homotopy functors in algebraic topology
- 55P91 Equivariant homotopy theory in algebraic topology [See also 19L47]
- 55P92 Relations between equivariant and nonequivariant homotopy theory in algebraic topology
- 55P99 None of the above, but in this section

## 55Qxx Homotopy groups

- 55Q05 Homotopy groups, general; sets of homotopy classes
- 55Q07 Shape groups
- 55Q10 Stable homotopy groups
- 55Q15 Whitehead products and generalizations
- 55Q20 Homotopy groups of wedges, joins, and simple spaces
- 55Q25 Hopf invariants
- 55Q35 Operations in homotopy groups
- 55Q40 Homotopy groups of spheres
- 55Q45 Stable homotopy of spheres
- 55Q50  $J$ -morphism [See also 19L20]
- 55Q51  $v_n$ -periodicity
- 55Q52 Homotopy groups of special spaces
- 55Q55 Cohomotopy groups
- 55Q70 Homotopy groups of special types [See also 55N05, 55N07]
- 55Q91 Equivariant homotopy groups [See also 19L47]
- 55Q99 None of the above, but in this section

## 55Rxx Fiber spaces and bundles in algebraic topology [See also 18F15, 32Lxx, 46M20, 57R20, 57R22, 57R25]

- 55R05 Fiber spaces in algebraic topology
- 55R10 Fiber bundles in algebraic topology
- 55R12 Transfer for fiber spaces and bundles in algebraic topology
- 55R15 Classification of fiber spaces or bundles in algebraic topology
- 55R20 Spectral sequences and homology of fiber spaces in algebraic topology [See also 55Txx]
- 55R25 Sphere bundles and vector bundles in algebraic topology
- 55R35 Classifying spaces of groups and  $H$ -spaces in algebraic topology
- 55R37 Maps between classifying spaces in algebraic topology

- 55R40** Homology of classifying spaces and characteristic classes in algebraic topology [See also [57Txx](#), [57R20](#)]
- 55R45** Homology and homotopy of  $BO$  and  $BU$ ; Bott periodicity
- 55R50** Stable classes of vector space bundles in algebraic topology and relations to  $K$ -theory [See also [19Lxx](#)] {For algebraic  $K$ -theory, see [18F25](#), [19-XX](#)}
- 55R55** Fiberings with singularities in algebraic topology
- 55R60** Microbundles and block bundles in algebraic topology [See also [57N55](#), [57Q50](#)]
- 55R65** Generalizations of fiber spaces and bundles in algebraic topology
- 55R70** Fibrewise topology
- 55R80** Discriminantal varieties and configuration spaces in algebraic topology
- 55R91** Equivariant fiber spaces and bundles in algebraic topology [See also [19L47](#)]
- 55R99** None of the above, but in this section

### **55Sxx Operations and obstructions in algebraic topology**

- 55S05** Primary cohomology operations in algebraic topology
- 55S10** Steenrod algebra
- 55S12** Dyer-Lashof operations
- 55S15** Symmetric products and cyclic products in algebraic topology
- 55S20** Secondary and higher cohomology operations in algebraic topology
- 55S25**  $K$ -theory operations and generalized cohomology operations in algebraic topology [See also [19D55](#), [19Lxx](#)]
- 55S30** Massey products
- 55S35** Obstruction theory in algebraic topology
- 55S36** Extension and compression of mappings in algebraic topology
- 55S37** Classification of mappings in algebraic topology
- 55S40** Sectioning fiber spaces and bundles in algebraic topology
- 55S45** Postnikov systems,  $k$ -invariants
- 55S91** Equivariant operations and obstructions in algebraic topology [See also [19L47](#)]
- 55S99** None of the above, but in this section

### **55Txx Spectral sequences in algebraic topology [See also [18G40](#), [55R20](#)]**

- 55T05** General theory of spectral sequences in algebraic topology
- 55T10** Serre spectral sequences
- 55T15** Adams spectral sequences
- 55T20** Eilenberg-Moore spectral sequences [See also [57T35](#)]
- 55T25** Generalized cohomology and spectral sequences in algebraic topology
- 55T99** None of the above, but in this section

### **55Uxx Applied homological algebra and category theory in algebraic topology [See also [18Gxx](#)]**

- 55U05** Abstract complexes in algebraic topology
- 55U10** Simplicial sets and complexes in algebraic topology
- 55U15** Chain complexes in algebraic topology
- 55U20** Universal coefficient theorems, Bockstein operator
- 55U25** Homology of a product, Künneth formula
- 55U30** Duality in applied homological algebra and category theory (aspects of algebraic topology)
- 55U35** Abstract and axiomatic homotopy theory in algebraic topology
- 55U40** Topological categories, foundations of homotopy theory
- 55U99** None of the above, but in this section

### **57-XX Manifolds and cell complexes {For complex manifolds, see [32Qxx](#)}**

- 57-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to manifolds and cell complexes
- 57-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to manifolds and cell complexes
- 57-02** Research exposition (monographs, survey articles) pertaining to manifolds and cell complexes
- 57-03** History of manifolds and cell complexes [Consider also classification numbers pertaining to [Section 01](#)]
- 57-04** Software, source code, etc. for problems pertaining to manifolds and cell complexes
- 57-06** Proceedings, conferences, collections, etc. pertaining to manifolds and cell complexes
- 57-08** Computational methods for problems pertaining to manifolds and cell complexes
- 57-11** Research data for problems pertaining to manifolds and cell complexes

## 57Kxx Low-dimensional topology in specific dimensions

- 57K10 Knot theory
- 57K12 Generalized knots (virtual knots, welded knots, quandles, etc.)
- 57K14 Knot polynomials
- 57K16 Finite-type and quantum invariants, topological quantum field theories (TQFT)
- 57K18 Homology theories in knot theory (Khovanov, Heegaard-Floer, etc.)
- 57K20 2-dimensional topology (including mapping class groups of surfaces, Teichmüller theory, curve complexes, etc.)
- 57K30 General topology of 3-manifolds
- 57K31 Invariants of 3-manifolds (also skein modules; character varieties)
- 57K32 Hyperbolic 3-manifolds
- 57K33 Contact structures in 3 dimensions [See also 57R17]
- 57K35 Other geometric structures on 3-manifolds
- 57K40 General topology of 4-manifolds
- 57K41 Invariants of 4-manifolds (e.g., Donaldson and Seiberg-Witten invariants)
- 57K43 Symplectic structures in 4 dimensions [See also 57R17]
- 57K45 Higher-dimensional knots and links
- 57K50 Low-dimensional manifolds of specific dimension 5 or higher
- 57K99 None of the above, but in this section

## 57Mxx General low-dimensional topology

- 57M05 Fundamental group, presentations, free differential calculus
- 57M07 Topological methods in group theory
- 57M10 Covering spaces and low-dimensional topology
- 57M12 Low-dimensional topology of special (e.g., branched) coverings
- 57M15 Relations of low-dimensional topology with graph theory [See also 05Cxx]
- 57M30 Wild embeddings
- 57M50 General geometric structures on low-dimensional manifolds
- 57M60 Group actions on manifolds and cell complexes in low dimensions
- 57M99 None of the above, but in this section

## 57Nxx Topological manifolds

- 57N16 Geometric structures on manifolds of high or arbitrary dimension [See also 57M50]
- 57N17 Topology of topological vector spaces
- 57N20 Topology of infinite-dimensional manifolds [See also 58Bxx]
- 57N25 Shapes (aspects of topological manifolds) [See also 54C56, 55P55, 55Q07]
- 57N30 Engulfing in topological manifolds
- 57N35 Embeddings and immersions in topological manifolds
- 57N37 Isotopy and pseudo-isotopy
- 57N40 Neighborhoods of submanifolds
- 57N45 Flatness and tameness of topological manifolds
- 57N50  $S^{n-1} \subset E^n$ , Schoenflies problem
- 57N55 Microbundles and block bundles [See also 55R60, 57Q50]
- 57N60 Cellularity in topological manifolds
- 57N65 Algebraic topology of manifolds
- 57N70 Cobordism and concordance in topological manifolds
- 57N75 General position and transversality
- 57N80 Stratifications in topological manifolds
- 57N99 None of the above, but in this section

## 57Pxx Generalized manifolds [See also 18F15]

- 57P05 Local properties of generalized manifolds
- 57P10 Poincaré duality spaces
- 57P99 None of the above, but in this section

## 57Qxx PL-topology

- 57Q05 General topology of complexes
- 57Q10 Simple homotopy type, Whitehead torsion, Reidemeister-Franz torsion, etc. [See also 19B28]
- 57Q12 Wall finiteness obstruction for CW-complexes
- 57Q15 Triangulating manifolds
- 57Q20 Cobordism in PL-topology
- 57Q25 Comparison of PL-structures: classification, Hauptvermutung
- 57Q30 Engulfing
- 57Q35 Embeddings and immersions in PL-topology
- 57Q37 Isotopy in PL-topology
- 57Q40 Regular neighborhoods in PL-topology
- 57Q50 Microbundles and block bundles [See also 55R60, 57N55]
- 57Q55 Approximations in PL-topology
- 57Q60 Cobordism and concordance in PL-topology

- 57Q65** General position and transversality
- 57Q70** Discrete Morse theory and related ideas in manifold topology
- 57Q91** Equivariant PL-topology
- 57Q99** None of the above, but in this section
- 57Rxx Differential topology {For foundational questions of differentiable manifolds, see [58Axx](#); for infinite-dimensional manifolds, see [58Bxx](#)}**
- 57R05** Triangulating
- 57R10** Smoothing in differential topology
- 57R12** Smooth approximations in differential topology
- 57R15** Specialized structures on manifolds (spin manifolds, framed manifolds, etc.)
- 57R17** Symplectic and contact topology in high or arbitrary dimension [See also [57K33](#), [57K43](#)]
- 57R18** Topology and geometry of orbifolds
- 57R19** Algebraic topology on manifolds and differential topology
- 57R20** Characteristic classes and numbers in differential topology
- 57R22** Topology of vector bundles and fiber bundles [See also [55Rxx](#)]
- 57R25** Vector fields, frame fields in differential topology
- 57R27** Controllability of vector fields on  $C^\infty$  and real-analytic manifolds [See also [49Qxx](#), [37C10](#), [93B05](#)]
- 57R30** Foliations in differential topology; geometric theory [See also [53C12](#)]
- 57R32** Classifying spaces for foliations; Gelfand-Fuks cohomology [See also [58H10](#)]
- 57R35** Differentiable mappings in differential topology
- 57R40** Embeddings in differential topology
- 57R42** Immersions in differential topology
- 57R45** Singularities of differentiable mappings in differential topology
- 57R50** Differential topological aspects of diffeomorphisms
- 57R52** Isotopy in differential topology
- 57R55** Differentiable structures in differential topology
- 57R56** Topological quantum field theories (aspects of differential topology)
- 57R57** Applications of global analysis to structures on manifolds [See also [57K41](#), [58-XX](#)]
- 57R58** Floer homology
- 57R60** Homotopy spheres, Poincaré conjecture
- 57R65** Surgery and handlebodies
- 57R67** Surgery obstructions, Wall groups [See also [19J25](#)]
- 57R70** Critical points and critical submanifolds in differential topology
- 57R75** O- and SO-cobordism
- 57R77** Complex cobordism (U- and SU-cobordism) [See also [55N22](#)]
- 57R80**  $h$ - and  $s$ -cobordism
- 57R85** Equivariant cobordism
- 57R90** Other types of cobordism [See also [55N22](#)]
- 57R91** Equivariant algebraic topology of manifolds
- 57R95** Realizing cycles by submanifolds
- 57R99** None of the above, but in this section
- 57Sxx Topological transformation groups [See also [20F34](#), [22-XX](#), [37-XX](#), [54H15](#), [58D05](#)]**
- 57S05** Topological properties of groups of homeomorphisms or diffeomorphisms
- 57S10** Compact groups of homeomorphisms
- 57S12** Toric topology
- 57S15** Compact Lie groups of differentiable transformations
- 57S17** Finite transformation groups
- 57S20** Noncompact Lie groups of transformations
- 57S25** Groups acting on specific manifolds
- 57S30** Discontinuous groups of transformations
- 57S99** None of the above, but in this section
- 57Txx Homology and homotopy of topological groups and related structures**
- 57T05** Hopf algebras (aspects of homology and homotopy of topological groups) [See also [16T05](#)]
- 57T10** Homology and cohomology of Lie groups
- 57T15** Homology and cohomology of homogeneous spaces of Lie groups
- 57T20** Homotopy groups of topological groups and homogeneous spaces
- 57T25** Homology and cohomology of  $H$ -spaces
- 57T30** Bar and cobar constructions [See also [18N40](#), [55Uxx](#)]
- 57T35** Applications of Eilenberg-Moore spectral sequences [See also [55R20](#), [55T20](#)]
- 57T99** None of the above, but in this section
- 57Zxx Relations of manifolds and cell complexes with science and engineering**
- 57Z05** Relations of manifolds and cell complexes with physics
- 57Z10** Relations of manifolds and cell complexes with biology
- 57Z15** Relations of manifolds and cell complexes with chemistry

- 57Z20** Relations of manifolds and cell complexes with engineering
- 57Z25** Relations of manifolds and cell complexes with computer and data science
- 57Z99** None of the above, but in this section

**58-XX Global analysis, analysis on manifolds** [See also [32Cxx](#), [32Fxx](#), [32Wxx](#), [46-XX](#), [47Hxx](#), [53Cxx](#)] {For geometric integration theory, see [49Q15](#)}

- 58-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to global analysis
- 58-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to global analysis
- 58-02** Research exposition (monographs, survey articles) pertaining to global analysis
- 58-03** History of global analysis [Consider also classification numbers pertaining to Section [01](#)]
- 58-04** Software, source code, etc. for problems pertaining to global analysis
- 58-06** Proceedings, conferences, collections, etc. pertaining to global analysis
- 58-08** Computational methods for problems pertaining to global analysis
- 58-11** Research data for problems pertaining to global analysis

**58Axx General theory of differentiable manifolds** [See also [32Cxx](#)]

- 58A03** Topos-theoretic approach to differentiable manifolds
- 58A05** Differentiable manifolds, foundations
- 58A07** Real-analytic and Nash manifolds [See also [14P20](#), [32C07](#)]
- 58A10** Differential forms in global analysis
- 58A12** de Rham theory in global analysis [See also [14Fxx](#)]
- 58A14** Hodge theory in global analysis [See also [14C30](#), [14Fxx](#), [32J25](#), [32S35](#)]
- 58A15** Exterior differential systems (Cartan theory)
- 58A17** Pfaffian systems
- 58A20** Jets in global analysis
- 58A25** Currents in global analysis [See also [32C30](#), [53C65](#)]
- 58A30** Vector distributions (subbundles of the tangent bundles)
- 58A32** Natural bundles
- 58A35** Stratified sets [See also [32S60](#)]

- 58A40** Differential spaces
- 58A50** Supermanifolds and graded manifolds [See also [14A22](#), [32C11](#)]
- 58A99** None of the above, but in this section

**58Bxx Infinite-dimensional manifolds**

- 58B05** Homotopy and topological questions for infinite-dimensional manifolds
- 58B10** Differentiability questions for infinite-dimensional manifolds
- 58B12** Questions of holomorphy and infinite-dimensional manifolds [See also [32-XX](#), [46G20](#)]
- 58B15** Fredholm structures on infinite-dimensional manifolds [See also [47A53](#)]
- 58B20** Riemannian, Finsler and other geometric structures on infinite-dimensional manifolds [See also [53C20](#), [53C60](#)]
- 58B25** Group structures and generalizations on infinite-dimensional manifolds [See also [22E65](#), [58D05](#)]
- 58B32** Geometry of quantum groups
- 58B34** Noncommutative geometry (à la Connes)
- 58B99** None of the above, but in this section

**58Cxx Calculus on manifolds; nonlinear operators** [See also [46Txx](#), [47Hxx](#), [47Jxx](#)]

- 58C05** Real-valued functions on manifolds
- 58C06** Set-valued and function-space-valued mappings on manifolds [See also [47H04](#), [54C60](#)]
- 58C07** Continuity properties of mappings on manifolds
- 58C10** Holomorphic maps on manifolds [See also [32-XX](#)]
- 58C15** Implicit function theorems; global Newton methods on manifolds
- 58C20** Differentiation theory (Gateaux, Fréchet, etc.) on manifolds [See also [26Exx](#), [46G05](#)]
- 58C25** Differentiable maps on manifolds
- 58C30** Fixed-point theorems on manifolds [See also [47H10](#)]
- 58C35** Integration on manifolds; measures on manifolds [See also [28Cxx](#)]
- 58C40** Spectral theory; eigenvalue problems on manifolds [See also [47J10](#), [58E07](#)]
- 58C50** Analysis on supermanifolds or graded manifolds
- 58C99** None of the above, but in this section



- 58Dxx Spaces and manifolds of mappings (including nonlinear versions of 46Exx)** [See also 46Txx, 53Cxx]
- 58D05** Groups of diffeomorphisms and homeomorphisms as manifolds [See also 22E65, 57S05]
- 58D07** Groups and semigroups of nonlinear operators [See also 17B65, 47H20]
- 58D10** Spaces of embeddings and immersions
- 58D15** Manifolds of mappings [See also 46T10, 54C35]
- 58D17** Manifolds of metrics (especially Riemannian)
- 58D19** Group actions and symmetry properties
- 58D20** Measures (Gaussian, cylindrical, etc.) on manifolds of maps [See also 28Cxx, 46T12]
- 58D25** Equations in function spaces; evolution equations [See also 34Gxx, 35K90, 35L90, 35R15, 37Lxx, 47Jxx]
- 58D27** Moduli problems for differential geometric structures
- 58D29** Moduli problems for topological structures
- 58D30** Applications of manifolds of mappings to the sciences
- 58D99** None of the above, but in this section
- 58Exx Variational problems in infinite-dimensional spaces**
- 58E05** Abstract critical point theory (Morse theory, Lyusternik-Shnirel'man theory, etc.) in infinite-dimensional spaces
- 58E07** Variational problems in abstract bifurcation theory in infinite-dimensional spaces
- 58E09** Group-invariant bifurcation theory in infinite-dimensional spaces
- 58E10** Variational problems in applications to the theory of geodesics (problems in one independent variable)
- 58E11** Critical metrics
- 58E12** Variational problems concerning minimal surfaces (problems in two independent variables) [See also 49Q05]
- 58E15** Variational problems concerning extremal problems in several variables; Yang-Mills functionals [See also 81T13], etc.
- 58E17** Multiobjective variational problems, Pareto optimality, applications to economics, etc. [See also 90C29, 91Bxx]
- 58E20** Harmonic maps, etc. [See also 53C43]
- 58E25** Applications of variational problems to control theory [See also 49-XX, 93-XX]
- 58E30** Variational principles in infinite-dimensional spaces
- 58E35** Variational inequalities (global problems) in infinite-dimensional spaces
- 58E40** Variational aspects of group actions in infinite-dimensional spaces
- 58E50** Applications of variational problems in infinite-dimensional spaces to the sciences
- 58E99** None of the above, but in this section
- 58Hxx Pseudogroups, differentiable groupoids and general structures on manifolds**
- 58H05** Pseudogroups and differentiable groupoids [See also 22A22, 22E65]
- 58H10** Cohomology of classifying spaces for pseudogroup structures (Spencer, Gelfand-Fuks, etc.) [See also 57R32]
- 58H15** Deformations of general structures on manifolds [See also 32Gxx, 58J10]
- 58H99** None of the above, but in this section
- 58Jxx Partial differential equations on manifolds; differential operators** [See also 32Wxx, 35-XX, 53Cxx]
- 58J05** Elliptic equations on manifolds, general theory [See also 35-XX]
- 58J10** Differential complexes [See also 35Nxx]; elliptic complexes
- 58J15** Relations of PDEs on manifolds with hyperfunctions
- 58J20** Index theory and related fixed-point theorems on manifolds [See also 19K56, 46L80]
- 58J22** Exotic index theories on manifolds [See also 19K56, 46L05, 46L10, 46L80, 46M20]
- 58J26** Elliptic genera
- 58J28** Eta-invariants, Chern-Simons invariants
- 58J30** Spectral flows
- 58J32** Boundary value problems on manifolds
- 58J35** Heat and other parabolic equation methods for PDEs on manifolds
- 58J37** Perturbations of PDEs on manifolds; asymptotics
- 58J40** Pseudodifferential and Fourier integral operators on manifolds [See also 35Sxx]
- 58J42** Noncommutative global analysis, noncommutative residues
- 58J45** Hyperbolic equations on manifolds [See also 35Lxx]
- 58J47** Propagation of singularities; initial value problems on manifolds
- 58J50** Spectral problems; spectral geometry; scattering theory on manifolds [See also 35Pxx]
- 58J51** Relations between spectral theory and ergodic theory, e.g., quantum unique ergodicity
- 58J52** Determinants and determinant bundles, analytic torsion
- 58J53** Isospectrality

- 58J55** Bifurcation theory for PDEs on manifolds [See also [35B32](#)]
- 58J60** Relations of PDEs with special manifold structures (Riemannian, Finsler, etc.)
- 58J65** Diffusion processes and stochastic analysis on manifolds [See also [35R60](#), [60H10](#), [60J60](#)]
- 58J70** Invariance and symmetry properties for PDEs on manifolds [See also [35A30](#)]
- 58J72** Correspondences and other transformation methods (e.g., Lie-Bäcklund) for PDEs on manifolds [See also [35A22](#)]
- 58J90** Applications of PDEs on manifolds
- 58J99** None of the above, but in this section

## **58Kxx Theory of singularities and catastrophe theory** [See also [32Sxx](#), [37-XX](#)]

- 58K05** Critical points of functions and mappings on manifolds
- 58K10** Monodromy on manifolds
- 58K15** Topological properties of mappings on manifolds
- 58K20** Algebraic and analytic properties of mappings on manifolds
- 58K25** Stability theory for manifolds
- 58K30** Global theory of singularities
- 58K35** Catastrophe theory
- 58K40** Classification; finite determinacy of map germs
- 58K45** Singularities of vector fields, topological aspects
- 58K50** Normal forms on manifolds
- 58K55** Asymptotic behavior of solutions to equations on manifolds
- 58K60** Deformation of singularities
- 58K65** Topological invariants on manifolds
- 58K70** Symmetries, equivariance on manifolds
- 58K99** None of the above, but in this section

## **58Zxx Applications of global analysis to the sciences**

- 58Z05** Applications of global analysis to the sciences
- 58Z99** None of the above, but in this section

## **60-XX Probability theory and stochastic processes** {For additional applications, see [05Cxx](#), [11Kxx](#), [34-XX](#), [35-XX](#), [62-XX](#), [90-XX](#), [76-XX](#), [81-XX](#), [82-XX](#), [91-XX](#), [92-XX](#), [93-XX](#), [94-XX](#)}

- 60-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to probability theory

- 60-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to probability theory
- 60-02** Research exposition (monographs, survey articles) pertaining to probability theory
- 60-03** History of probability theory [Consider also classification numbers pertaining to Section [01](#)]
- 60-04** Software, source code, etc. for problems pertaining to probability theory
- 60-06** Proceedings, conferences, collections, etc. pertaining to probability theory
- 60-08** Computational methods for problems pertaining to probability theory
- 60-11** Research data for problems pertaining to probability theory

## **60Axx Foundations of probability theory**

- 60A05** Axioms; other general questions in probability
- 60A10** Probabilistic measure theory {For ergodic theory, see [28Dxx](#), [60Fxx](#)}
- 60A86** Fuzzy probability
- 60A99** None of the above, but in this section

## **60Bxx Probability theory on algebraic and topological structures**

- 60B05** Probability measures on topological spaces
- 60B10** Convergence of probability measures
- 60B11** Probability theory on linear topological spaces [See also [28C20](#)]
- 60B12** Limit theorems for vector-valued random variables (infinite-dimensional case)
- 60B15** Probability measures on groups or semigroups, Fourier transforms, factorization
- 60B20** Random matrices (probabilistic aspects) {For algebraic aspects, see [15B52](#)}
- 60B99** None of the above, but in this section

## **60Cxx Combinatorial probability**

- 60C05** Combinatorial probability
- 60C99** None of the above, but in this section

## **60Dxx Geometric probability and stochastic geometry** [See also [52A22](#), [53C65](#)]

- 60D05** Geometric probability and stochastic geometry [See also [52A22](#), [53C65](#)]
- 60D99** None of the above, but in this section

## **60Exx** Distribution theory [See also [62Exx](#), [62Hxx](#)]

- 60E05** Probability distributions: general theory
- 60E07** Infinitely divisible distributions; stable distributions
- 60E10** Characteristic functions; other transforms
- 60E15** Inequalities; stochastic orderings
- 60E99** None of the above, but in this section

## **60Fxx** Limit theorems in probability theory [See also [28Dxx](#), [60B12](#)]

- 60F05** Central limit and other weak theorems
- 60F10** Large deviations
- 60F15** Strong limit theorems
- 60F17** Functional limit theorems; invariance principles
- 60F20** Zero-one laws
- 60F25**  $L^p$ -limit theorems
- 60F99** None of the above, but in this section

## **60Gxx** Stochastic processes

- 60G05** Foundations of stochastic processes
- 60G07** General theory of stochastic processes
- 60G09** Exchangeability for stochastic processes
- 60G10** Stationary stochastic processes
- 60G12** General second-order stochastic processes
- 60G15** Gaussian processes
- 60G17** Sample path properties
- 60G18** Self-similar stochastic processes
- 60G20** Generalized stochastic processes
- 60G22** Fractional processes, including fractional Brownian motion
- 60G25** Prediction theory (aspects of stochastic processes) [See also [62M20](#)]
- 60G30** Continuity and singularity of induced measures
- 60G35** Signal detection and filtering (aspects of stochastic processes) [See also [62M20](#), [93E10](#), [93E11](#), [94Axx](#)]
- 60G40** Stopping times; optimal stopping problems; gambling theory [See also [62L15](#), [91A60](#)]
- 60G42** Martingales with discrete parameter
- 60G44** Martingales with continuous parameter
- 60G46** Martingales and classical analysis
- 60G48** Generalizations of martingales
- 60G50** Sums of independent random variables; random walks
- 60G51** Processes with independent increments; Lévy processes
- 60G52** Stable stochastic processes

- 60G53** Feller processes
- 60G55** Point processes (e.g., Poisson, Cox, Hawkes processes)
- 60G57** Random measures
- 60G60** Random fields
- 60G65** Nonlinear processes (e.g.,  $G$ -Brownian motion,  $G$ -Lévy processes)
- 60G70** Extreme value theory; extremal stochastic processes
- 60G99** None of the above, but in this section

## **60Hxx** Stochastic analysis [See also [58J65](#)]

- 60H05** Stochastic integrals
- 60H07** Stochastic calculus of variations and the Malliavin calculus
- 60H10** Stochastic ordinary differential equations (aspects of stochastic analysis) [See also [34F05](#)]
- 60H15** Stochastic partial differential equations (aspects of stochastic analysis) [See also [35R60](#)]
- 60H17** Singular stochastic partial differential equations
- 60H20** Stochastic integral equations
- 60H25** Random operators and equations (aspects of stochastic analysis) [See also [47B80](#)]
- 60H30** Applications of stochastic analysis (to PDEs, etc.)
- 60H35** Computational methods for stochastic equations (aspects of stochastic analysis) [See also [65C30](#)]
- 60H40** White noise theory
- 60H50** Regularization by noise
- 60H99** None of the above, but in this section

## **60Jxx** Markov processes

- 60J05** Discrete-time Markov processes on general state spaces
- 60J10** Markov chains (discrete-time Markov processes on discrete state spaces)
- 60J20** Applications of Markov chains and discrete-time Markov processes on general state spaces (social mobility, learning theory, industrial processes, etc.) [See also [90B30](#), [91D10](#), [91E40](#)]
- 60J22** Computational methods in Markov chains [See also [65C40](#)]
- 60J25** Continuous-time Markov processes on general state spaces
- 60J27** Continuous-time Markov processes on discrete state spaces
- 60J28** Applications of continuous-time Markov processes on discrete state spaces
- 60J35** Transition functions, generators and resolvents [See also [47D03](#), [47D07](#)]
- 60J40** Right processes
- 60J45** Probabilistic potential theory [See also [31Cxx](#), [31D05](#)]
- 60J46** Dirichlet form methods in Markov processes

- 60J50** Boundary theory for Markov processes
- 60J55** Local time and additive functionals
- 60J57** Multiplicative functionals and Markov processes
- 60J60** Diffusion processes [See also [58J65](#)]
- 60J65** Brownian motion [See also [58J65](#)]
- 60J67** Stochastic (Schramm-)Loewner evolution (SLE)
- 60J68** Superprocesses
- 60J70** Applications of Brownian motions and diffusion theory (population genetics, absorption problems, etc.) [See also [92Dxx](#)]
- 60J75** Jump processes on discrete state spaces
- 60J76** Jump processes on general state spaces
- 60J80** Branching processes (Galton-Watson, birth-and-death, etc.)
- 60J85** Applications of branching processes [See also [92Dxx](#)]
- 60J90** Coalescent processes
- 60J95** Applications of coalescent processes [See also [92Dxx](#)]
- 60J99** None of the above, but in this section

## 60Kxx Special processes

- 60K05** Renewal theory
- 60K10** Applications of renewal theory (reliability, demand theory, etc.)
- 60K15** Markov renewal processes, semi-Markov processes
- 60K20** Applications of Markov renewal processes (reliability, queueing networks, etc.) [See also [90Bxx](#)]
- 60K25** Queueing theory (aspects of probability theory) [See also [68M20](#), [90B22](#)]
- 60K30** Applications of queueing theory (congestion, allocation, storage, traffic, etc.) [See also [90Bxx](#)]
- 60K35** Interacting random processes; statistical mechanics type models; percolation theory [See also [82B43](#), [82C43](#)]
- 60K37** Processes in random environments
- 60K40** Other physical applications of random processes
- 60K50** Anomalous diffusion models (subdiffusion, superdiffusion, continuous-time random walks, etc.) [See also [60G22](#), [60G55](#), [60J75](#)] {For applications to physics and the sciences, see [76-XX](#), [82Cxx](#), [92-XX](#)}
- 60K99** None of the above, but in this section

## 60Lxx Rough analysis

- 60L10** Signatures and data streams
- 60L20** Rough paths
- 60L30** Regularity structures
- 60L40** Paracontrolled distributions and alternative approaches
- 60L50** Rough partial differential equations
- 60L70** Algebraic structures and computation
- 60L90** Applications of rough analysis
- 60L99** None of the above, but in this section

## 62-XX Statistics

- 62-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to statistics
- 62-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to statistics
- 62-02** Research exposition (monographs, survey articles) pertaining to statistics
- 62-03** History of statistics [Consider also classification numbers pertaining to Section [01](#)]
- 62-04** Software, source code, etc. for problems pertaining to statistics
- 62-06** Proceedings, conferences, collections, etc. pertaining to statistics
- 62-08** Computational methods for problems pertaining to statistics
- 62-11** Research data for problems pertaining to statistics

## 62Axx Foundational and philosophical topics in statistics

- 62A01** Foundations and philosophical topics in statistics
- 62A09** Graphical methods
- 62A86** Fuzzy analysis in statistics
- 62A99** None of the above, but in this section

## 62Bxx Sufficiency and information

- 62B05** Sufficient statistics and fields
- 62B10** Statistical aspects of information-theoretic topics [See also [94A17](#)]
- 62B11** Information geometry (statistical aspects) {For differential geometric aspects, see [53B12](#)}
- 62B15** Theory of statistical experiments
- 62B86** Statistical aspects of fuzziness, sufficiency, and information
- 62B99** None of the above, but in this section

## 62Cxx Statistical decision theory [See also [90B50](#), [91B06](#)] {For game theory, see [91A35](#)}

- 62C05** General considerations in statistical decision theory
- 62C07** Complete class results in statistical decision theory
- 62C10** Bayesian problems; characterization of Bayes procedures
- 62C12** Empirical decision procedures; empirical Bayes procedures
- 62C15** Admissibility in statistical decision theory
- 62C20** Minimax procedures in statistical decision theory
- 62C25** Compound decision problems in statistical decision theory
- 62C86** Statistical decision theory and fuzziness
- 62C99** None of the above, but in this section

## **62Dxx Statistical sampling theory, sample surveys**

- 62D05** Sampling theory, sample surveys
- 62D10** Missing data
- 62D20** Causal inference from observational studies
- 62D99** None of the above, but in this section

## **62Exx Statistical distribution theory [See also [60Exx](#)]**

- 62E10** Characterization and structure theory of statistical distributions
- 62E15** Exact distribution theory in statistics
- 62E17** Approximations to statistical distributions (nonasymptotic)
- 62E20** Asymptotic distribution theory in statistics
- 62E86** Fuzziness in connection with statistical distributions
- 62E99** None of the above, but in this section

## **62Fxx Parametric inference**

- 62F03** Parametric hypothesis testing
- 62F05** Asymptotic properties of parametric tests
- 62F07** Statistical ranking and selection procedures
- 62F10** Point estimation
- 62F12** Asymptotic properties of parametric estimators
- 62F15** Bayesian inference
- 62F25** Parametric tolerance and confidence regions
- 62F30** Parametric inference under constraints
- 62F35** Robustness and adaptive procedures (parametric inference)
- 62F40** Bootstrap, jackknife and other resampling methods
- 62F86** Parametric inference and fuzziness
- 62F99** None of the above, but in this section

## **62Gxx Nonparametric inference**

- 62G05** Nonparametric estimation
- 62G07** Density estimation
- 62G08** Nonparametric regression and quantile regression
- 62G09** Nonparametric statistical resampling methods
- 62G10** Nonparametric hypothesis testing
- 62G15** Nonparametric tolerance and confidence regions
- 62G20** Asymptotic properties of nonparametric inference
- 62G30** Order statistics; empirical distribution functions
- 62G32** Statistics of extreme values; tail inference
- 62G35** Nonparametric robustness
- 62G86** Nonparametric inference and fuzziness
- 62G99** None of the above, but in this section

## **62Hxx Multivariate analysis [See also [60Exx](#)]**

- 62H05** Characterization and structure theory for multivariate probability distributions; copulas
- 62H10** Multivariate distribution of statistics
- 62H11** Directional data; spatial statistics
- 62H12** Estimation in multivariate analysis
- 62H15** Hypothesis testing in multivariate analysis
- 62H17** Contingency tables
- 62H20** Measures of association (correlation, canonical correlation, etc.)
- 62H22** Probabilistic graphical models
- 62H25** Factor analysis and principal components; correspondence analysis
- 62H30** Classification and discrimination; cluster analysis (statistical aspects) [See also [68T10](#), [91C20](#)]; mixture models
- 62H35** Image analysis in multivariate analysis
- 62H86** Multivariate analysis and fuzziness
- 62H99** None of the above, but in this section

## **62Jxx Linear inference, regression**

- 62J02** General nonlinear regression
- 62J05** Linear regression; mixed models
- 62J07** Ridge regression; shrinkage estimators (Lasso)
- 62J10** Analysis of variance and covariance (ANOVA)
- 62J12** Generalized linear models (logistic models)
- 62J15** Paired and multiple comparisons; multiple testing
- 62J20** Diagnostics, and linear inference and regression
- 62J86** Fuzziness, and linear inference and regression
- 62J99** None of the above, but in this section

## **62Kxx Design of statistical experiments [See also [05Bxx](#)]**

- 62K05** Optimal statistical designs
- 62K10** Statistical block designs
- 62K15** Factorial statistical designs
- 62K20** Response surface designs
- 62K25** Robust parameter designs
- 62K86** Fuzziness and design of statistical experiments
- 62K99** None of the above, but in this section



## **62Lxx Sequential statistical methods**

- 62L05** Sequential statistical design
- 62L10** Sequential statistical analysis
- 62L12** Sequential estimation
- 62L15** Optimal stopping in statistics [See also [60G40](#), [91A60](#)]
- 62L20** Stochastic approximation
- 62L86** Fuzziness and sequential statistical methods
- 62L99** None of the above, but in this section

## **62Mxx Inference from stochastic processes**

- 62M02** Markov processes: hypothesis testing
- 62M05** Markov processes: estimation; hidden Markov models
- 62M07** Non-Markovian processes: hypothesis testing
- 62M09** Non-Markovian processes: estimation
- 62M10** Time series, auto-correlation, regression, etc. in statistics (GARCH) [See also [91B84](#)]
- 62M15** Inference from stochastic processes and spectral analysis
- 62M20** Inference from stochastic processes and prediction [See also [60G25](#)]; filtering [See also [60G35](#), [93E10](#), [93E11](#)]
- 62M30** Inference from spatial processes
- 62M40** Random fields; image analysis
- 62M45** Neural nets and related approaches to inference from stochastic processes
- 62M86** Inference from stochastic processes and fuzziness
- 62M99** None of the above, but in this section

## **62Nxx Survival analysis and censored data**

- 62N01** Censored data models
- 62N02** Estimation in survival analysis and censored data
- 62N03** Testing in survival analysis and censored data
- 62N05** Reliability and life testing [See also [90B25](#)]
- 62N86** Fuzziness, and survival analysis and censored data
- 62N99** None of the above, but in this section

## **62Pxx Applications of statistics [See also [90-XX](#), [91-XX](#), [92-XX](#)]**

- 62P05** Applications of statistics to actuarial sciences and financial mathematics
- 62P10** Applications of statistics to biology and medical sciences; meta analysis
- 62P12** Applications of statistics to environmental and related topics
- 62P15** Applications of statistics to psychology

**62P20** Applications of statistics to economics [See also [91Bxx](#)]

**62P25** Applications of statistics to social sciences

**62P30** Applications of statistics in engineering and industry; control charts

**62P35** Applications of statistics to physics

**62P99** None of the above, but in this section

## **62Qxx Statistical tables**

**62Q05** Statistical tables

**62Q99** None of the above, but in this section

## **62Rxx Statistics on algebraic and topological structures**

**62R01** Algebraic statistics

**62R07** Statistical aspects of big data and data science {For computer science aspects, see [68T09](#); for information-theoretic aspects, see [94A16](#)}

**62R10** Functional data analysis

**62R20** Statistics on metric spaces

**62R30** Statistics on manifolds

**62R40** Topological data analysis [See also [55N31](#)]

**62R99** None of the above, but in this section

## **65-XX Numerical analysis**

**65-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to numerical analysis

**65-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to numerical analysis

**65-02** Research exposition (monographs, survey articles) pertaining to numerical analysis

**65-03** History of numerical analysis [Consider also classification numbers pertaining to Section [01](#)]

**65-04** Software, source code, etc. for problems pertaining to numerical analysis

**65-06** Proceedings, conferences, collections, etc. pertaining to numerical analysis

**65-11** Research data for problems pertaining to numerical analysis

## **65Axx Tables in numerical analysis**

**65A05** Tables in numerical analysis

**65A99** None of the above, but in this section

## **65Bxx Acceleration of convergence in numerical analysis**

- 65B05** Extrapolation to the limit, deferred corrections
- 65B10** Numerical summation of series
- 65B15** Euler-Maclaurin formula in numerical analysis
- 65B99** None of the above, but in this section

## **65Cxx Probabilistic methods, stochastic differential equations**

- 65C05** Monte Carlo methods [See also [82M31](#)]
- 65C10** Random number generation in numerical analysis [See also [11K45](#)]
- 65C20** Probabilistic models, generic numerical methods in probability and statistics [See also [60-08](#), [62-08](#)]
- 65C30** Numerical solutions to stochastic differential and integral equations {For theoretical aspects, see [60H35](#)} [See also [65M75](#), [65N75](#)]
- 65C35** Stochastic particle methods [See also [82M60](#)]
- 65C40** Numerical analysis or methods applied to Markov chains [See also [60J22](#)]
- 65C99** None of the above, but in this section

## **65Dxx Numerical approximation and computational geometry (primarily algorithms) {For theoretical aspects, see [41-XX](#), [68Uxx](#)}**

- 65D05** Numerical interpolation
- 65D07** Numerical computation using splines
- 65D10** Numerical smoothing, curve fitting
- 65D12** Numerical radial basis function approximation
- 65D15** Algorithms for approximation of functions
- 65D17** Computer-aided design (modeling of curves and surfaces) [See also [68U07](#)]
- 65D18** Numerical aspects of computer graphics, image analysis, and computational geometry [See also [51N05](#), [68U05](#)]
- 65D19** Computational issues in computer and robotic vision
- 65D20** Computation of special functions and constants, construction of tables [See also [33F05](#)]
- 65D25** Numerical differentiation
- 65D30** Numerical integration
- 65D32** Numerical quadrature and cubature formulas
- 65D40** High-dimensional functions; sparse grids
- 65D99** None of the above, but in this section

## **65Exx Numerical methods in complex analysis (potential theory, etc.)**

- 65E05** Numerical methods in complex analysis (potential theory, etc.) [See also [30-08](#), [31-08](#), [32-08](#)]
- 65E10** Numerical methods in conformal mappings [See also [30C30](#)]
- 65E99** None of the above, but in this section

## **65Fxx Numerical linear algebra**

- 65F05** Direct numerical methods for linear systems and matrix inversion
- 65F08** Preconditioners for iterative methods
- 65F10** Iterative numerical methods for linear systems [See also [65N22](#)]
- 65F15** Numerical computation of eigenvalues and eigenvectors of matrices
- 65F18** Numerical solutions to inverse eigenvalue problems
- 65F20** Numerical solutions to overdetermined systems, pseudoinverses
- 65F22** Ill-posedness and regularization problems in numerical linear algebra
- 65F25** Orthogonalization in numerical linear algebra
- 65F30** Other numerical matrix algorithms
- 65F35** Numerical computation of matrix norms, conditioning, scaling [See also [15A12](#), [15A60](#)]
- 65F40** Numerical computation of determinants
- 65F45** Numerical methods for matrix equations
- 65F50** Computational methods for sparse matrices
- 65F55** Numerical methods for low-rank matrix approximation; matrix compression
- 65F60** Numerical computation of matrix exponential and similar matrix functions
- 65F99** None of the above, but in this section

## **65Gxx Error analysis and interval analysis**

- 65G20** Algorithms with automatic result verification
- 65G30** Interval and finite arithmetic
- 65G40** General methods in interval analysis
- 65G50** Roundoff error
- 65G99** None of the above, but in this section

## **65Hxx Nonlinear algebraic or transcendental equations**

- 65H04** Numerical computation of roots of polynomial equations
- 65H05** Numerical computation of solutions to single equations

- 65H10** Numerical computation of solutions to systems of equations
- 65H14** Numerical algebraic geometry
- 65H17** Numerical solution of nonlinear eigenvalue and eigenvector problems [See also [47Hxx](#), [47Jxx](#), [58C40](#), [58E07](#), [90C30](#)]
- 65H20** Global methods, including homotopy approaches to the numerical solution of nonlinear equations [See also [58C30](#), [90C30](#)]
- 65H99** None of the above, but in this section
- 65Jxx Numerical analysis in abstract spaces**
- 65J05** General theory of numerical analysis in abstract spaces
- 65J08** Numerical solutions to abstract evolution equations
- 65J10** Numerical solutions to equations with linear operators (do not use [65Fxx](#))
- 65J15** Numerical solutions to equations with nonlinear operators (do not use [65Hxx](#))
- 65J20** Numerical solutions of ill-posed problems in abstract spaces; regularization
- 65J22** Numerical solution to inverse problems in abstract spaces
- 65J99** None of the above, but in this section
- 65Kxx Numerical methods for mathematical programming, optimization and variational techniques**
- 65K05** Numerical mathematical programming methods [See also [90Cxx](#)]
- 65K10** Numerical optimization and variational techniques [See also [49Mxx](#), [93-08](#)]
- 65K15** Numerical methods for variational inequalities and related problems
- 65K99** None of the above, but in this section
- 65Lxx Numerical methods for ordinary differential equations**
- 65L03** Numerical methods for functional-differential equations
- 65L04** Numerical methods for stiff equations
- 65L05** Numerical methods for initial value problems
- 65L06** Multistep, Runge-Kutta and extrapolation methods for ordinary differential equations
- 65L07** Numerical investigation of stability of solutions
- 65L08** Numerical solution of ill-posed problems involving ordinary differential equations
- 65L09** Numerical solution of inverse problems involving ordinary differential equations
- 65L10** Numerical solution of boundary value problems involving ordinary differential equations
- 65L11** Numerical solution of singularly perturbed problems involving ordinary differential equations
- 65L12** Finite difference and finite volume methods for ordinary differential equations
- 65L15** Numerical solution of eigenvalue problems involving ordinary differential equations
- 65L20** Stability and convergence of numerical methods for ordinary differential equations
- 65L50** Mesh generation, refinement, and adaptive methods for ordinary differential equations
- 65L60** Finite element, Rayleigh-Ritz, Galerkin and collocation methods for ordinary differential equations
- 65L70** Error bounds for numerical methods for ordinary differential equations
- 65L80** Numerical methods for differential-algebraic equations
- 65L99** None of the above, but in this section
- 65Mxx Numerical methods for partial differential equations, initial value and time-dependent initial-boundary value problems**
- 65M06** Finite difference methods for initial value and initial-boundary value problems involving PDEs
- 65M08** Finite volume methods for initial value and initial-boundary value problems involving PDEs
- 65M12** Stability and convergence of numerical methods for initial value and initial-boundary value problems involving PDEs
- 65M15** Error bounds for initial value and initial-boundary value problems involving PDEs
- 65M20** Method of lines for initial value and initial-boundary value problems involving PDEs
- 65M22** Numerical solution of discretized equations for initial value and initial-boundary value problems involving PDEs [See also [65Fxx](#), [65Hxx](#)]
- 65M25** Numerical aspects of the method of characteristics for initial value and initial-boundary value problems involving PDEs
- 65M30** Numerical methods for ill-posed problems for initial value and initial-boundary value problems involving PDEs
- 65M32** Numerical methods for inverse problems for initial value and initial-boundary value problems involving PDEs
- 65M38** Boundary element methods for initial value and initial-boundary value problems involving PDEs

- 65M50** Mesh generation, refinement, and adaptive methods for the numerical solution of initial value and initial-boundary value problems involving PDEs
- 65M55** Multigrid methods; domain decomposition for initial value and initial-boundary value problems involving PDEs
- 65M60** Finite element, Rayleigh-Ritz and Galerkin methods for initial value and initial-boundary value problems involving PDEs
- 65M70** Spectral, collocation and related methods for initial value and initial-boundary value problems involving PDEs
- 65M75** Probabilistic methods, particle methods, etc. for initial value and initial-boundary value problems involving PDEs
- 65M80** Fundamental solutions, Green's function methods, etc. for initial value and initial-boundary value problems involving PDEs
- 65M85** Fictitious domain methods for initial value and initial-boundary value problems involving PDEs
- 65M99** None of the above, but in this section
- 65Nxx Numerical methods for partial differential equations, boundary value problems**
- 65N06** Finite difference methods for boundary value problems involving PDEs
- 65N08** Finite volume methods for boundary value problems involving PDEs
- 65N12** Stability and convergence of numerical methods for boundary value problems involving PDEs
- 65N15** Error bounds for boundary value problems involving PDEs
- 65N20** Numerical methods for ill-posed problems for boundary value problems involving PDEs
- 65N21** Numerical methods for inverse problems for boundary value problems involving PDEs
- 65N22** Numerical solution of discretized equations for boundary value problems involving PDEs [See also [65Fxx](#), [65Hxx](#)]
- 65N25** Numerical methods for eigenvalue problems for boundary value problems involving PDEs
- 65N30** Finite element, Rayleigh-Ritz and Galerkin methods for boundary value problems involving PDEs
- 65N35** Spectral, collocation and related methods for boundary value problems involving PDEs
- 65N38** Boundary element methods for boundary value problems involving PDEs
- 65N40** Method of lines for boundary value problems involving PDEs
- 65N45** Method of contraction of the boundary for boundary value problems involving PDEs
- 65N50** Mesh generation, refinement, and adaptive methods for boundary value problems involving PDEs
- 65N55** Multigrid methods; domain decomposition for boundary value problems involving PDEs
- 65N75** Probabilistic methods, particle methods, etc. for boundary value problems involving PDEs
- 65N80** Fundamental solutions, Green's function methods, etc. for boundary value problems involving PDEs
- 65N85** Fictitious domain methods for boundary value problems involving PDEs
- 65N99** None of the above, but in this section
- 65Pxx Numerical problems in dynamical systems [See also [37Mxx](#)]**
- 65P10** Numerical methods for Hamiltonian systems including symplectic integrators
- 65P20** Numerical chaos
- 65P30** Numerical bifurcation problems
- 65P40** Numerical nonlinear stabilities in dynamical systems
- 65P99** None of the above, but in this section
- 65Qxx Numerical methods for difference and functional equations, recurrence relations**
- 65Q10** Numerical methods for difference equations
- 65Q20** Numerical methods for functional equations
- 65Q30** Numerical aspects of recurrence relations
- 65Q99** None of the above, but in this section
- 65Rxx Numerical methods for integral equations, integral transforms**
- 65R10** Numerical methods for integral transforms
- 65R15** Numerical methods for eigenvalue problems in integral equations
- 65R20** Numerical methods for integral equations
- 65R30** Numerical methods for ill-posed problems for integral equations
- 65R32** Numerical methods for inverse problems for integral equations
- 65R99** None of the above, but in this section
- 65Sxx Graphical methods in numerical analysis**
- 65S05** Graphical methods in numerical analysis
- 65S99** None of the above, but in this section

## **65Txx Numerical methods in Fourier analysis**

- 65T40** Numerical methods for trigonometric approximation and interpolation
- 65T50** Numerical methods for discrete and fast Fourier transforms
- 65T60** Numerical methods for wavelets
- 65T99** None of the above, but in this section

## **65Yxx Computer aspects of numerical algorithms**

- 65Y04** Numerical algorithms for computer arithmetic, etc. [See also [68M07](#)]
- 65Y05** Parallel numerical computation
- 65Y10** Numerical algorithms for specific classes of architectures
- 65Y15** Packaged methods for numerical algorithms
- 65Y20** Complexity and performance of numerical algorithms [See also [68Q25](#)]
- 65Y99** None of the above, but in this section

## **65Zxx Applications to the sciences**

- 65Z05** Applications to the sciences
- 65Z99** None of the above, but in this section

## **68-XX Computer science {For papers containing software, source code, etc. in a specific mathematical area, see the classification number -04 in that area}**

- 68-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to computer science
- 68-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to computer science
- 68-02** Research exposition (monographs, survey articles) pertaining to computer science
- 68-03** History of computer science [Consider also classification numbers pertaining to Section [01](#)]
- 68-04** Software, source code, etc. for problems pertaining to computer science
- 68-06** Proceedings, conferences, collections, etc. pertaining to computer science
- 68-11** Research data for problems pertaining to computer science

## **68Mxx Computer system organization**

- 68M01** General theory of computer systems
- 68M07** Mathematical problems of computer architecture [See also [68W35](#)]
- 68M10** Network design and communication in computer systems [See also [68R10](#), [90B18](#)]
- 68M11** Internet topics [See also [68U35](#)]
- 68M12** Network protocols
- 68M14** Distributed systems
- 68M15** Reliability, testing and fault tolerance of networks and computer systems
- 68M18** Wireless sensor networks as related to computer science [See also [90B18](#), [90B80](#)]
- 68M20** Performance evaluation, queueing, and scheduling in the context of computer systems [See also [60K20](#), [60K25](#), [90B22](#), [90B35](#), [90B36](#)]
- 68M25** Computer security
- 68M99** None of the above, but in this section

## **68Nxx Theory of software**

- 68N01** General topics in the theory of software
- 68N15** Theory of programming languages
- 68N17** Logic programming
- 68N18** Functional programming and lambda calculus [See also [03B40](#)]
- 68N19** Other programming paradigms (object-oriented, sequential, concurrent, automatic, etc.)
- 68N20** Theory of compilers and interpreters
- 68N25** Theory of operating systems
- 68N30** Mathematical aspects of software engineering (specification, verification, metrics, requirements, etc.)
- 68N99** None of the above, but in this section

## **68Pxx Theory of data**

- 68P01** General topics in the theory of data
- 68P05** Data structures
- 68P10** Searching and sorting
- 68P15** Database theory
- 68P20** Information storage and retrieval of data
- 68P25** Data encryption (aspects in computer science) [See also [81P94](#), [94A60](#)]
- 68P27** Privacy of data
- 68P30** Coding and information theory (compaction, compression, models of communication, encoding schemes, etc.) (aspects in computer science) [See also [94Axx](#), [94Bxx](#)]
- 68P99** None of the above, but in this section



## 68Qxx Theory of computing

- 68Q01 General topics in the theory of computing
- 68Q04 Classical models of computation (Turing machines, etc.) [See also [03D10](#)]
- 68Q06 Networks and circuits as models of computation; circuit complexity [See also [94C11](#)]
- 68Q07 Biologically inspired models of computation (DNA computing, membrane computing, etc.)
- 68Q09 Other nonclassical models of computation {For quantum computing, see mainly [68Q12](#), [81P68](#)}
- 68Q10 Modes of computation (nondeterministic, parallel, interactive, probabilistic, etc.) [See also [68Q85](#)]
- 68Q11 Communication complexity, information complexity
- 68Q12 Quantum algorithms and complexity in the theory of computing [See also [68Q09](#), [81P68](#)]
- 68Q15 Complexity classes (hierarchies, relations among complexity classes, etc.) [See also [03D15](#), [68Q17](#), [68Q19](#)]
- 68Q17 Computational difficulty of problems (lower bounds, completeness, difficulty of approximation, etc.) [See also [68Q15](#)]
- 68Q19 Descriptive complexity and finite models [See also [03C13](#)]
- 68Q25 Analysis of algorithms and problem complexity [See also [68W40](#)]
- 68Q27 Parameterized complexity, tractability and kernelization
- 68Q30 Algorithmic information theory (Kolmogorov complexity, etc.) [See also [03D32](#)]
- 68Q32 Computational learning theory [See also [68T05](#)]
- 68Q42 Grammars and rewriting systems
- 68Q45 Formal languages and automata [See also [03D05](#), [68Q70](#), [94A45](#)]
- 68Q55 Semantics in the theory of computing [See also [03B70](#), [06B35](#), [18C50](#)]
- 68Q60 Specification and verification (program logics, model checking, etc.) [See also [03B70](#)]
- 68Q65 Abstract data types; algebraic specification [See also [18C50](#)]
- 68Q70 Algebraic theory of languages and automata [See also [18B20](#), [20M35](#)]
- 68Q80 Cellular automata (computational aspects) {For cellular automata as dynamical systems, see [37B15](#)}
- 68Q85 Models and methods for concurrent and distributed computing (process algebras, bisimulation, transition nets, etc.)
- 68Q87 Probability in computer science (algorithm analysis, random structures, phase transitions, etc.) [See also [68W20](#), [68W40](#)]
- 68Q99 None of the above, but in this section

## 68Rxx Discrete mathematics in relation to computer science

- 68R01 General topics of discrete mathematics in relation to computer science
- 68R05 Combinatorics in computer science
- 68R07 Computational aspects of satisfiability [See also [68T20](#)]
- 68R10 Graph theory (including graph drawing) in computer science [See also [05Cxx](#), [90B10](#), [90C35](#)]
- 68R12 Metric embeddings as related to computational problems and algorithms
- 68R15 Combinatorics on words
- 68R99 None of the above, but in this section

## 68Txx Artificial intelligence

- 68T01 General topics in artificial intelligence
- 68T05 Learning and adaptive systems in artificial intelligence [See also [68Q32](#)]
- 68T07 Artificial neural networks and deep learning
- 68T09 Computational aspects of data analysis and big data [See also [62R07](#)] {For homological aspects, see [55N31](#)}
- 68T10 Pattern recognition, speech recognition {For cluster analysis, see [62H30](#)}
- 68T20 Problem solving in the context of artificial intelligence (heuristics, search strategies, etc.)
- 68T27 Logic in artificial intelligence
- 68T30 Knowledge representation
- 68T35 Theory of languages and software systems (knowledge-based systems, expert systems, etc.) for artificial intelligence
- 68T37 Reasoning under uncertainty in the context of artificial intelligence
- 68T40 Artificial intelligence for robotics [See also [93C85](#)]
- 68T42 Agent technology and artificial intelligence
- 68T45 Machine vision and scene understanding
- 68T50 Natural language processing [See also [03B65](#), [91F20](#)]
- 68T99 None of the above, but in this section

## 68Uxx Computing methodologies and applications

- 68U01 General topics in computing methodologies
- 68U03 Computational aspects of digital topology {For topological aspects, see [54H30](#); for homological aspects, see [55-XX](#)}
- 68U05 Computer graphics; computational geometry (digital and algorithmic aspects) {For methods of numerical mathematics, see [65D18](#)}

- 68U07** Computer science aspects of computer-aided design  
{For methods of numerical mathematics, see [65D17](#)}
- 68U10** Computing methodologies for image processing
- 68U15** Computing methodologies for text processing; mathematical typography
- 68U35** Computing methodologies for information systems  
(hypertext navigation, interfaces, decision support, etc.)  
[See also [68M11](#)]
- 68U99** None of the above, but in this section

## **68Vxx Computer science support for mathematical research and practice**

- 68V05** Computer assisted proofs of proofs-by-exhaustion type  
{For rigorous numerics, see [65Gxx](#); for proofs employing automated or interactive theorem provers, see [68V15](#)}
- 68V15** Theorem proving (automated and interactive theorem provers, deduction, resolution, etc.) [See also [03B35](#)]
- 68V20** Formalization of mathematics in connection with theorem provers [See also [03B35](#), [68V15](#)]
- 68V25** Presentation and content markup for mathematics
- 68V30** Mathematical knowledge management
- 68V35** Digital mathematics libraries and repositories
- 68V99** None of the above, but in this section

## **68Wxx Algorithms in computer science {For numerical algorithms, see [65-XX](#); for combinatorics and graph theory, see [05C85](#), [68Rxx](#)}**

- 68W01** General topics in the theory of algorithms
- 68W05** Nonnumerical algorithms
- 68W10** Parallel algorithms in computer science
- 68W15** Distributed algorithms
- 68W20** Randomized algorithms
- 68W25** Approximation algorithms
- 68W27** Online algorithms; streaming algorithms
- 68W30** Symbolic computation and algebraic computation  
[See also [11Yxx](#), [12-08](#), [13Pxx](#), [14Qxx](#), [16Z05](#), [17-08](#), [33F10](#)]
- 68W32** Algorithms on strings
- 68W35** Hardware implementations of nonnumerical algorithms (VLSI algorithms, etc.) [See also [68M07](#)]
- 68W40** Analysis of algorithms [See also [68Q25](#)]
- 68W50** Evolutionary algorithms, genetic algorithms (computational aspects) [See also [68T05](#), [68T20](#), [90C59](#)]
- 68W99** None of the above, but in this section

## **70-XX Mechanics of particles and systems {For relativistic mechanics, see [83A05](#), [83C10](#); for statistical mechanics, see [82-XX](#)}**

- 70-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to mechanics of particles and systems
- 70-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to mechanics of particles and systems
- 70-02** Research exposition (monographs, survey articles) pertaining to mechanics of particles and systems
- 70-03** History of mechanics of particles and systems [Consider also classification numbers pertaining to Section [01](#)]
- 70-04** Software, source code, etc. for problems pertaining to mechanics of particles and systems
- 70-05** Experimental work for problems pertaining to mechanics of particles and systems
- 70-06** Proceedings, conferences, collections, etc. pertaining to mechanics of particles and systems
- 70-08** Computational methods for problems pertaining to mechanics of particles and systems
- 70-10** Mathematical modeling or simulation for problems pertaining to mechanics of particles and systems
- 70-11** Research data for problems pertaining to mechanics of particles and systems

## **70Axx Axiomatics, foundations**

- 70A05** Axiomatics, foundations
- 70A99** None of the above, but in this section

## **70Bxx Kinematics [See also [53A17](#)]**

- 70B05** Kinematics of a particle
- 70B10** Kinematics of a rigid body
- 70B15** Kinematics of mechanisms and robots [See also [68T40](#), [70Q05](#), [93C85](#)]
- 70B99** None of the above, but in this section

## **70Cxx Statics**

- 70C20** Statics
- 70C99** None of the above, but in this section

## **70Exx Dynamics of a rigid body and of multibody systems**

- 70E05** Motion of the gyroscope
- 70E15** Free motion of a rigid body [See also [70M20](#)]
- 70E17** Motion of a rigid body with a fixed point
- 70E18** Motion of a rigid body in contact with a solid surface [See also [70F25](#)]
- 70E20** Perturbation methods for rigid body dynamics
- 70E40** Integrable cases of motion in rigid body dynamics
- 70E45** Higher-dimensional generalizations in rigid body dynamics
- 70E50** Stability problems in rigid body dynamics
- 70E55** Dynamics of multibody systems
- 70E60** Robot dynamics and control of rigid bodies [See also [68T40](#), [70Q05](#), [93C85](#)]
- 70E99** None of the above, but in this section

## **70Fxx Dynamics of a system of particles, including celestial mechanics**

- 70F05** Two-body problems
- 70F07** Three-body problems
- 70F10**  $n$ -body problems
- 70F15** Celestial mechanics
- 70F16** Collisions in celestial mechanics, regularization
- 70F17** Inverse problems for systems of particles
- 70F20** Holonomic systems related to the dynamics of a system of particles
- 70F25** Nonholonomic systems related to the dynamics of a system of particles
- 70F35** Collision of rigid or pseudo-rigid bodies
- 70F40** Problems involving a system of particles with friction
- 70F45** The dynamics of infinite particle systems
- 70F99** None of the above, but in this section

## **70Gxx General models, approaches, and methods [See also [37-XX](#)]**

- 70G10** Generalized coordinates; event, impulse-energy, configuration, state, or phase space for problems in mechanics
- 70G40** Topological and differential topological methods for problems in mechanics
- 70G45** Differential geometric methods (tensors, connections, symplectic, Poisson, contact, Riemannian, nonholonomic, etc.) for problems in mechanics [See also [53Cxx](#), [53Dxx](#), [58Axx](#)]
- 70G55** Algebraic geometry methods for problems in mechanics

- 70G60** Dynamical systems methods for problems in mechanics
- 70G65** Symmetries, Lie group and Lie algebra methods for problems in mechanics
- 70G70** Functional analytic methods for problems in mechanics
- 70G75** Variational methods for problems in mechanics
- 70G99** None of the above, but in this section

## **70Hxx Hamiltonian and Lagrangian mechanics [See also [37Jxx](#)]**

- 70H03** Lagrange's equations
- 70H05** Hamilton's equations
- 70H06** Completely integrable systems and methods of integration for problems in Hamiltonian and Lagrangian mechanics
- 70H07** Nonintegrable systems for problems in Hamiltonian and Lagrangian mechanics
- 70H08** Nearly integrable Hamiltonian systems, KAM theory
- 70H09** Perturbation theories for problems in Hamiltonian and Lagrangian mechanics
- 70H11** Adiabatic invariants for problems in Hamiltonian and Lagrangian mechanics
- 70H12** Periodic and almost periodic solutions for problems in Hamiltonian and Lagrangian mechanics
- 70H14** Stability problems for problems in Hamiltonian and Lagrangian mechanics
- 70H15** Canonical and symplectic transformations for problems in Hamiltonian and Lagrangian mechanics
- 70H20** Hamilton-Jacobi equations in mechanics
- 70H25** Hamilton's principle
- 70H30** Other variational principles in mechanics
- 70H33** Symmetries and conservation laws, reverse symmetries, invariant manifolds and their bifurcations, reduction for problems in Hamiltonian and Lagrangian mechanics
- 70H40** Relativistic dynamics for problems in Hamiltonian and Lagrangian mechanics
- 70H45** Constrained dynamics, Dirac's theory of constraints [See also [70F20](#), [70F25](#), [70Gxx](#)]
- 70H50** Higher-order theories for problems in Hamiltonian and Lagrangian mechanics
- 70H99** None of the above, but in this section

## **70Jxx Linear vibration theory**

- 70J10** Modal analysis in linear vibration theory
- 70J25** Stability for problems in linear vibration theory
- 70J30** Free motions in linear vibration theory
- 70J35** Forced motions in linear vibration theory

- 70J40** Parametric resonances in linear vibration theory
- 70J50** Systems arising from the discretization of structural vibration problems
- 70J99** None of the above, but in this section

**70Kxx Nonlinear dynamics in mechanics** [See also [34Cxx](#), [37-XX](#)]

- 70K05** Phase plane analysis, limit cycles for nonlinear problems in mechanics
- 70K20** Stability for nonlinear problems in mechanics
- 70K25** Free motions for nonlinear problems in mechanics
- 70K28** Parametric resonances for nonlinear problems in mechanics
- 70K30** Nonlinear resonances for nonlinear problems in mechanics
- 70K40** Forced motions for nonlinear problems in mechanics
- 70K42** Equilibria and periodic trajectories for nonlinear problems in mechanics
- 70K43** Quasi-periodic motions and invariant tori for nonlinear problems in mechanics
- 70K44** Homoclinic and heteroclinic trajectories for nonlinear problems in mechanics
- 70K45** Normal forms for nonlinear problems in mechanics
- 70K50** Bifurcations and instability for nonlinear problems in mechanics
- 70K55** Transition to stochasticity (chaotic behavior) for nonlinear problems in mechanics [See also [37D45](#)]
- 70K60** General perturbation schemes for nonlinear problems in mechanics
- 70K65** Averaging of perturbations for nonlinear problems in mechanics
- 70K70** Systems with slow and fast motions for nonlinear problems in mechanics
- 70K75** Nonlinear modes
- 70K99** None of the above, but in this section

**70Lxx Random and stochastic aspects of the mechanics of particles and systems**

- 70L05** Random vibrations in mechanics of particles and systems [See also [74H50](#)]
- 70L10** Stochastic geometric mechanics
- 70L99** None of the above, but in this section

**70Mxx Orbital mechanics**

- 70M20** Orbital mechanics
- 70M99** None of the above, but in this section

**70Pxx Variable mass, rockets**

- 70P05** Variable mass, rockets
- 70P99** None of the above, but in this section

**70Qxx Control of mechanical systems** [See also [60Gxx](#), [60Jxx](#)]

- 70Q05** Control of mechanical systems
- 70Q99** None of the above, but in this section

**70Sxx Classical field theories** [See also [37Kxx](#), [37Lxx](#), [78-XX](#), [81Txx](#), [83-XX](#)]

- 70S05** Lagrangian formalism and Hamiltonian formalism in mechanics of particles and systems
- 70S10** Symmetries and conservation laws in mechanics of particles and systems
- 70S15** Yang-Mills and other gauge theories in mechanics of particles and systems
- 70S20** More general nonquantum field theories in mechanics of particles and systems
- 70S99** None of the above, but in this section

**74-XX Mechanics of deformable solids**

- 74-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to mechanics of deformable solids
- 74-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to mechanics of deformable solids
- 74-02** Research exposition (monographs, survey articles) pertaining to mechanics of deformable solids
- 74-03** History of mechanics of deformable solids [Consider also classification numbers pertaining to [Section 01](#)]
- 74-04** Software, source code, etc. for problems pertaining to mechanics of deformable solids
- 74-05** Experimental work for problems pertaining to mechanics of deformable solids
- 74-06** Proceedings, conferences, collections, etc. pertaining to mechanics of deformable solids
- 74-10** Mathematical modeling or simulation for problems pertaining to mechanics of deformable solids
- 74-11** Research data for problems pertaining to mechanics of deformable solids

## **74Axx Generalities, axiomatics, foundations of continuum mechanics of solids**

- 74A05 Kinematics of deformation
- 74A10 Stress
- 74A15 Thermodynamics in solid mechanics
- 74A20 Theory of constitutive functions in solid mechanics
- 74A25 Molecular, statistical, and kinetic theories in solid mechanics
- 74A30 Nonsimple materials
- 74A35 Polar materials
- 74A40 Random materials and composite materials
- 74A45 Theories of fracture and damage
- 74A50 Structured surfaces and interfaces, coexistent phases
- 74A55 Theories of friction (tribology)
- 74A60 Micromechanical theories
- 74A65 Reactive materials
- 74A70 Peridynamics
- 74A99 None of the above, but in this section

## **74Bxx Elastic materials**

- 74B05 Classical linear elasticity
- 74B10 Linear elasticity with initial stresses
- 74B15 Equations linearized about a deformed state (small deformations superposed on large)
- 74B20 Nonlinear elasticity
- 74B99 None of the above, but in this section

## **74Cxx Plastic materials, materials of stress-rate and internal-variable type**

- 74C05 Small-strain, rate-independent theories of plasticity (including rigid-plastic and elasto-plastic materials)
- 74C10 Small-strain, rate-dependent theories of plasticity (including theories of viscoplasticity)
- 74C15 Large-strain, rate-independent theories of plasticity (including nonlinear plasticity)
- 74C20 Large-strain, rate-dependent theories of plasticity
- 74C99 None of the above, but in this section

## **74Dxx Materials of strain-rate type and history type, other materials with memory (including elastic materials with viscous damping, various viscoelastic materials)**

- 74D05 Linear constitutive equations for materials with memory
- 74D10 Nonlinear constitutive equations for materials with memory
- 74D99 None of the above, but in this section

## **74Exx Material properties given special treatment**

- 74E05 Inhomogeneity in solid mechanics
- 74E10 Anisotropy in solid mechanics
- 74E15 Crystalline structure
- 74E20 Granularity
- 74E25 Texture in solid mechanics
- 74E30 Composite and mixture properties
- 74E35 Random structure in solid mechanics
- 74E40 Chemical structure in solid mechanics
- 74E99 None of the above, but in this section

## **74Fxx Coupling of solid mechanics with other effects**

- 74F05 Thermal effects in solid mechanics
- 74F10 Fluid-solid interactions (including aero- and hydro-elasticity, porosity, etc.)
- 74F15 Electromagnetic effects in solid mechanics
- 74F20 Mixture effects in solid mechanics
- 74F25 Chemical and reactive effects in solid mechanics
- 74F99 None of the above, but in this section

## **74Gxx Equilibrium (steady-state) problems in solid mechanics**

- 74G05 Explicit solutions of equilibrium problems in solid mechanics
- 74G10 Analytic approximation of solutions (perturbation methods, asymptotic methods, series, etc.) of equilibrium problems in solid mechanics
- 74G15 Numerical approximation of solutions of equilibrium problems in solid mechanics
- 74G25 Existence of solutions of equilibrium problems in solid mechanics
- 74G30 Uniqueness of solutions of equilibrium problems in solid mechanics
- 74G35 Multiplicity of solutions of equilibrium problems in solid mechanics
- 74G40 Regularity of solutions of equilibrium problems in solid mechanics
- 74G45 Bounds for solutions of equilibrium problems in solid mechanics
- 74G50 Saint-Venant's principle
- 74G55 Qualitative behavior of solutions of equilibrium problems in solid mechanics
- 74G60 Bifurcation and buckling
- 74G65 Energy minimization in equilibrium problems in solid mechanics
- 74G70 Stress concentrations, singularities in solid mechanics
- 74G75 Inverse problems in equilibrium solid mechanics
- 74G99 None of the above, but in this section



## **74Hxx Dynamical problems in solid mechanics**

- 74H05** Explicit solutions of dynamical problems in solid mechanics
- 74H10** Analytic approximation of solutions (perturbation methods, asymptotic methods, series, etc.) of dynamical problems in solid mechanics
- 74H15** Numerical approximation of solutions of dynamical problems in solid mechanics
- 74H20** Existence of solutions of dynamical problems in solid mechanics
- 74H25** Uniqueness of solutions of dynamical problems in solid mechanics
- 74H30** Regularity of solutions of dynamical problems in solid mechanics
- 74H35** Singularities, blow-up, stress concentrations for dynamical problems in solid mechanics
- 74H40** Long-time behavior of solutions for dynamical problems in solid mechanics
- 74H45** Vibrations in dynamical problems in solid mechanics
- 74H50** Random vibrations in dynamical problems in solid mechanics
- 74H55** Stability of dynamical problems in solid mechanics
- 74H60** Dynamical bifurcation of solutions to dynamical problems in solid mechanics
- 74H65** Chaotic behavior of solutions to dynamical problems in solid mechanics
- 74H75** Inverse problems in dynamical solid mechanics
- 74H80** Energy minimization in dynamical problems in solid mechanics
- 74H99** None of the above, but in this section

## **74Jxx Waves in solid mechanics**

- 74J05** Linear waves in solid mechanics
- 74J10** Bulk waves in solid mechanics
- 74J15** Surface waves in solid mechanics
- 74J20** Wave scattering in solid mechanics
- 74J25** Inverse problems for waves in solid mechanics
- 74J30** Nonlinear waves in solid mechanics
- 74J35** Solitary waves in solid mechanics
- 74J40** Shocks and related discontinuities in solid mechanics
- 74J99** None of the above, but in this section

## **74Kxx Thin bodies, structures**

- 74K05** Strings
- 74K10** Rods (beams, columns, shafts, arches, rings, etc.)
- 74K15** Membranes

- 74K20** Plates
- 74K25** Shells
- 74K30** Junctions
- 74K35** Thin films
- 74K99** None of the above, but in this section

## **74Lxx Special subfields of solid mechanics**

- 74L05** Geophysical solid mechanics [See also [86-XX](#)]
- 74L10** Soil and rock mechanics
- 74L15** Biomechanical solid mechanics [See also [92C10](#)]
- 74L99** None of the above, but in this section

## **74Mxx Special kinds of problems in solid mechanics**

- 74M05** Control, switches and devices (“smart materials”) in solid mechanics [See also [93Cxx](#)]
- 74M10** Friction in solid mechanics
- 74M15** Contact in solid mechanics
- 74M20** Impact in solid mechanics
- 74M25** Micromechanics of solids
- 74M99** None of the above, but in this section

## **74Nxx Phase transformations in solids** [See also [74A50](#), [80Axx](#), [82B26](#), [82C26](#)]

- 74N05** Crystals in solids
- 74N10** Displacive transformations in solids
- 74N15** Analysis of microstructure in solids
- 74N20** Dynamics of phase boundaries in solids
- 74N25** Transformations involving diffusion in solids
- 74N30** Problems involving hysteresis in solids
- 74N99** None of the above, but in this section

## **74Pxx Optimization problems in solid mechanics** [See also [49Qxx](#)]

- 74P05** Compliance or weight optimization in solid mechanics
- 74P10** Optimization of other properties in solid mechanics
- 74P15** Topological methods for optimization problems in solid mechanics
- 74P20** Geometrical methods for optimization problems in solid mechanics
- 74P99** None of the above, but in this section

## **74Qxx Homogenization, determination of effective properties in solid mechanics**

- 74Q05** Homogenization in equilibrium problems of solid mechanics
- 74Q10** Homogenization and oscillations in dynamical problems of solid mechanics
- 74Q15** Effective constitutive equations in solid mechanics
- 74Q20** Bounds on effective properties in solid mechanics
- 74Q99** None of the above, but in this section

## **74Rxx Fracture and damage**

- 74R05** Brittle damage
- 74R10** Brittle fracture
- 74R15** High-velocity fracture
- 74R20** Anelastic fracture and damage
- 74R99** None of the above, but in this section

## **74Sxx Numerical and other methods in solid mechanics [See also 65-XX, 74G15, 74H15]**

- 74S05** Finite element methods applied to problems in solid mechanics
- 74S10** Finite volume methods applied to problems in solid mechanics
- 74S15** Boundary element methods applied to problems in solid mechanics
- 74S20** Finite difference methods applied to problems in solid mechanics
- 74S22** Isogeometric methods applied to problems in solid mechanics
- 74S25** Spectral and related methods applied to problems in solid mechanics
- 74S30** Other numerical methods applied to problems in solid mechanics
- 74S40** Applications of fractional calculus in solid mechanics
- 74S50** Applications of graph theory in solid mechanics
- 74S60** Stochastic and other probabilistic methods applied to problems in solid mechanics
- 74S70** Complex-variable methods applied to problems in solid mechanics
- 74S99** None of the above, but in this section

## **76-XX Fluid mechanics {For general continuum mechanics, see 74Axx, or other parts of 74-XX}**

- 76-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to fluid mechanics

- 76-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to fluid mechanics
- 76-02** Research exposition (monographs, survey articles) pertaining to fluid mechanics
- 76-03** History of fluid mechanics [Consider also classification numbers pertaining to Section 01]
- 76-04** Software, source code, etc. for problems pertaining to fluid mechanics
- 76-05** Experimental work for problems pertaining to fluid mechanics
- 76-06** Proceedings, conferences, collections, etc. pertaining to fluid mechanics
- 76-10** Mathematical modeling or simulation for problems pertaining to fluid mechanics
- 76-11** Research data for problems pertaining to fluid mechanics

## **76Axx Foundations, constitutive equations, rheology, hydrodynamical models of non-fluid phenomena**

- 76A02** Foundations of fluid mechanics
- 76A05** Non-Newtonian fluids
- 76A10** Viscoelastic fluids
- 76A15** Liquid crystals [See also 82D30]
- 76A20** Thin fluid films
- 76A25** Superfluids (classical aspects)
- 76A30** Traffic and pedestrian flow models
- 76A99** None of the above, but in this section

## **76Bxx Incompressible inviscid fluids**

- 76B03** Existence, uniqueness, and regularity theory for incompressible inviscid fluids [See also 35Q35]
- 76B07** Free-surface potential flows for incompressible inviscid fluids
- 76B10** Jets and cavities, cavitation, free-streamline theory, water-entry problems, airfoil and hydrofoil theory, sloshing
- 76B15** Water waves, gravity waves; dispersion and scattering, nonlinear interaction [See also 35Q30]
- 76B20** Ship waves
- 76B25** Solitary waves for incompressible inviscid fluids [See also 35C11]
- 76B45** Capillarity (surface tension) for incompressible inviscid fluids [See also 76D45]
- 76B47** Vortex flows for incompressible inviscid fluids
- 76B55** Internal waves for incompressible inviscid fluids
- 76B70** Stratification effects in inviscid fluids
- 76B75** Flow control and optimization for incompressible inviscid fluids [See also 49Q10, 93C20, 93C95]
- 76B99** None of the above, but in this section

## 76Dxx Incompressible viscous fluids

- 76D03 Existence, uniqueness, and regularity theory for incompressible viscous fluids [See also 35Q30]
- 76D05 Navier-Stokes equations for incompressible viscous fluids [See also 35Q30]
- 76D06 Statistical solutions of Navier-Stokes and related equations [See also 60H30, 76M35]
- 76D07 Stokes and related (Oseen, etc.) flows
- 76D08 Lubrication theory
- 76D09 Viscous-inviscid interaction
- 76D10 Boundary-layer theory, separation and reattachment, higher-order effects
- 76D17 Viscous vortex flows
- 76D25 Wakes and jets
- 76D27 Other free boundary flows; Hele-Shaw flows
- 76D33 Waves for incompressible viscous fluids
- 76D45 Capillarity (surface tension) for incompressible viscous fluids [See also 76B45]
- 76D50 Stratification effects in viscous fluids
- 76D55 Flow control and optimization for incompressible viscous fluids [See also 49Q10, 93C20, 93C95]
- 76D99 None of the above, but in this section

## 76Exx Hydrodynamic stability

- 76E05 Parallel shear flows in hydrodynamic stability
- 76E06 Convection in hydrodynamic stability
- 76E07 Rotation in hydrodynamic stability
- 76E09 Stability and instability of nonparallel flows in hydrodynamic stability
- 76E15 Absolute and convective instability and stability in hydrodynamic stability
- 76E17 Interfacial stability and instability in hydrodynamic stability
- 76E19 Compressibility effects in hydrodynamic stability
- 76E20 Stability and instability of geophysical and astrophysical flows
- 76E25 Stability and instability of magnetohydrodynamic and electrohydrodynamic flows
- 76E30 Nonlinear effects in hydrodynamic stability
- 76E99 None of the above, but in this section

## 76Fxx Turbulence [See also 37-XX, 60Gxx, 60Jxx]

- 76F02 Fundamentals of turbulence
- 76F05 Isotropic turbulence; homogeneous turbulence
- 76F06 Transition to turbulence
- 76F10 Shear flows and turbulence

76F20 Dynamical systems approach to turbulence [See also 37-XX]

- 76F25 Turbulent transport, mixing
- 76F30 Renormalization and other field-theoretical methods for turbulence [See also 81T99]
- 76F35 Convective turbulence [See also 76E15, 76Rxx]
- 76F40 Turbulent boundary layers
- 76F45 Stratification effects in turbulence
- 76F50 Compressibility effects in turbulence
- 76F55 Statistical turbulence modeling [See also 76M35]
- 76F60  $k$ - $\varepsilon$  modeling in turbulence
- 76F65 Direct numerical and large eddy simulation of turbulence
- 76F70 Control of turbulent flows
- 76F80 Turbulent combustion; reactive turbulence
- 76F99 None of the above, but in this section

## 76Gxx General aerodynamics and subsonic flows

- 76G25 General aerodynamics and subsonic flows
- 76G99 None of the above, but in this section

## 76Hxx Transonic flows

- 76H05 Transonic flows
- 76H99 None of the above, but in this section

## 76Jxx Supersonic flows

- 76J20 Supersonic flows
- 76J99 None of the above, but in this section

## 76Kxx Hypersonic flows

- 76K05 Hypersonic flows
- 76K99 None of the above, but in this section

## 76Lxx Shock waves and blast waves in fluid mechanics [See also 35L67]

- 76L05 Shock waves and blast waves in fluid mechanics [See also 35L67]
- 76L99 None of the above, but in this section

## **76Mxx Basic methods in fluid mechanics** [See also [65-XX](#)]

- 76M10** Finite element methods applied to problems in fluid mechanics
- 76M12** Finite volume methods applied to problems in fluid mechanics
- 76M15** Boundary element methods applied to problems in fluid mechanics
- 76M20** Finite difference methods applied to problems in fluid mechanics
- 76M21** Inverse problems in fluid mechanics
- 76M22** Spectral methods applied to problems in fluid mechanics
- 76M23** Vortex methods applied to problems in fluid mechanics
- 76M25** Other numerical methods applied to problems in fluid mechanics
- 76M27** Visualization algorithms applied to problems in fluid mechanics
- 76M28** Particle methods and lattice-gas methods
- 76M30** Variational methods applied to problems in fluid mechanics
- 76M35** Stochastic analysis applied to problems in fluid mechanics
- 76M40** Complex variables methods applied to problems in fluid mechanics
- 76M45** Asymptotic methods, singular perturbations applied to problems in fluid mechanics
- 76M50** Homogenization applied to problems in fluid mechanics
- 76M55** Dimensional analysis and similarity applied to problems in fluid mechanics
- 76M60** Symmetry analysis, Lie group and Lie algebra methods applied to problems in fluid mechanics
- 76M99** None of the above, but in this section

## **76Nxx Compressible fluids and gas dynamics, general**

- 76N05** Compressible Navier-Stokes equations
- 76N10** Existence, uniqueness, and regularity theory for compressible fluids and gas dynamics [See also [35L60](#), [35L65](#), [35Q30](#)]
- 76N15** Gas dynamics, general
- 76N17** Viscous-inviscid interaction for compressible fluids and gas dynamics
- 76N20** Boundary-layer theory for compressible fluids and gas dynamics
- 76N25** Flow control and optimization for compressible fluids and gas dynamics
- 76N30** Waves in compressible fluids
- 76N99** None of the above, but in this section

## **76Pxx Rarefied gas flows, Boltzmann equation in fluid mechanics** [See also [82B40](#), [82C40](#), [82D05](#)]

- 76P05** Rarefied gas flows, Boltzmann equation in fluid mechanics [See also [82B40](#), [82C40](#), [82D05](#)]
- 76P99** None of the above, but in this section

## **76Qxx Hydro- and aero-acoustics**

- 76Q05** Hydro- and aero-acoustics
- 76Q99** None of the above, but in this section

## **76Rxx Diffusion and convection**

- 76R05** Forced convection
- 76R10** Free convection
- 76R50** Diffusion [See also [60J60](#)]
- 76R99** None of the above, but in this section

## **76Sxx Flows in porous media; filtration; seepage**

- 76S05** Flows in porous media; filtration; seepage
- 76S99** None of the above, but in this section

## **76Txx Multiphase and multicomponent flows**

- 76T05** Liquid-liquid two component flows
- 76T10** Liquid-gas two-phase flows, bubbly flows
- 76T15** Dusty-gas two-phase flows
- 76T17** Two gas multicomponent flows
- 76T20** Suspensions
- 76T25** Granular flows [See also [74C99](#), [74E20](#)]
- 76T30** Three or more component flows
- 76T99** None of the above, but in this section

## **76Uxx Rotating fluids**

- 76U05** Rotating fluids
- 76U60** Geophysical flows [See also [86A05](#), [86A10](#)]
- 76U65** Rossby waves [See also [86A05](#), [86A10](#)]
- 76U99** None of the above, but in this section

## **76Vxx Reaction effects in flows** [See also [80A32](#)]

- 76V05** Reaction effects in flows [See also [80A32](#)]
- 76V99** None of the above, but in this section

## **76Wxx Magnetohydrodynamics and electrohydrodynamics**

**76W05** Magnetohydrodynamics and electrohydrodynamics

**76W99** None of the above, but in this section

## **76Xxx Ionized gas flow in electromagnetic fields; plasmic flow [See also [82D10](#)]**

**76X05** Ionized gas flow in electromagnetic fields; plasmic flow [See also [82D10](#)]

**76X99** None of the above, but in this section

## **76Yxx Quantum hydrodynamics and relativistic hydrodynamics [See also [82D50](#), [83C55](#), [85A30](#)]**

**76Y05** Quantum hydrodynamics and relativistic hydrodynamics [See also [82D50](#), [83C55](#), [85A30](#)]

**76Y99** None of the above, but in this section

## **76Zxx Biological fluid mechanics [See also [74F10](#), [74L15](#), [92Cxx](#)]**

**76Z05** Physiological flows [See also [92C35](#)]

**76Z10** Biopropulsion in water and in air

**76Z99** None of the above, but in this section

## **78-XX Optics, electromagnetic theory {For quantum optics, see [81V80](#)}**

**78-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to optics and electromagnetic theory

**78-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to optics and electromagnetic theory

**78-02** Research exposition (monographs, survey articles) pertaining to optics and electromagnetic theory

**78-03** History of optics and electromagnetic theory [Consider also classification numbers pertaining to Section [01](#)]

**78-04** Software, source code, etc. for problems pertaining to optics and electromagnetic theory

**78-05** Experimental work for problems pertaining to optics and electromagnetic theory

**78-06** Proceedings, conferences, collections, etc. pertaining to optics and electromagnetic theory

**78-10** Mathematical modeling or simulation for problems pertaining to optics and electromagnetic theory

**78-11** Research data for problems pertaining to optics and electromagnetic theory

## **78Axx General**

**78A02** Foundations in optics and electromagnetic theory

**78A05** Geometric optics

**78A10** Physical optics

**78A15** Electron optics

**78A20** Space charge waves

**78A25** Electromagnetic theory, general

**78A30** Electro- and magnetostatics

**78A35** Motion of charged particles

**78A37** Ion traps

**78A40** Waves and radiation in optics and electromagnetic theory

**78A45** Diffraction, scattering {For WKB methods see [34E20](#)}

**78A46** Inverse problems (including inverse scattering) in optics and electromagnetic theory

**78A48** Composite media; random media in optics and electromagnetic theory

**78A50** Antennas, waveguides in optics and electromagnetic theory

**78A55** Technical applications of optics and electromagnetic theory

**78A57** Electrochemistry

**78A60** Lasers, masers, optical bistability, nonlinear optics [See also [81V80](#)]

**78A70** Biological applications of optics and electromagnetic theory [See also [91D30](#), [92C30](#)]

**78A97** Mathematically heuristic optics and electromagnetic theory (must also be assigned at least one other classification number in Section [78](#))

**78A99** None of the above, but in this section

## **78Mxx Basic methods for problems in optics and electromagnetic theory [See also [65-XX](#)]**

**78M05** Method of moments applied to problems in optics and electromagnetic theory

**78M10** Finite element, Galerkin and related methods applied to problems in optics and electromagnetic theory

**78M12** Finite volume methods, finite integration techniques applied to problems in optics and electromagnetic theory

**78M15** Boundary element methods applied to problems in optics and electromagnetic theory

**78M16** Multipole methods applied to problems in optics and electromagnetic theory

**78M20** Finite difference methods applied to problems in optics and electromagnetic theory

**78M22** Spectral, collocation and related methods applied to problems in optics and electromagnetic theory



- 78M25** Other numerical methods applied to problems in optics and electromagnetic theory
- 78M30** Variational methods applied to problems in optics and electromagnetic theory
- 78M31** Monte Carlo methods applied to problems in optics and electromagnetic theory
- 78M32** Neural and heuristic methods applied to problems in optics and electromagnetic theory
- 78M34** Model reduction in optics and electromagnetic theory
- 78M35** Asymptotic analysis in optics and electromagnetic theory
- 78M40** Homogenization in optics and electromagnetic theory
- 78M50** Optimization problems in optics and electromagnetic theory
- 78M99** None of the above, but in this section

## **80-XX Classical thermodynamics, heat transfer {For thermodynamics of solids, see [74A15](#)}**

- 80-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to classical thermodynamics
- 80-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to classical thermodynamics
- 80-02** Research exposition (monographs, survey articles) pertaining to classical thermodynamics
- 80-03** History of classical thermodynamics [Consider also classification numbers pertaining to Section [01](#)]
- 80-04** Software, source code, etc. for problems pertaining to classical thermodynamics
- 80-05** Experimental work for problems pertaining to classical thermodynamics
- 80-06** Proceedings, conferences, collections, etc. pertaining to classical thermodynamics
- 80-10** Mathematical modeling or simulation for problems pertaining to classical thermodynamics
- 80-11** Research data for problems pertaining to classical thermodynamics

### **80Axx Thermodynamics and heat transfer**

- 80A05** Foundations of thermodynamics and heat transfer
- 80A10** Classical and relativistic thermodynamics
- 80A17** Thermodynamics of continua [See also [74A15](#)]
- 80A20** Diffusive and convective heat and mass transfer, heat flow
- 80A22** Stefan problems, phase changes, etc. [See also [74Nxx](#)]
- 80A23** Inverse problems in thermodynamics and heat transfer

- 80A25** Combustion
- 80A30** Chemical kinetics in thermodynamics and heat transfer [See also [76V05](#), [92C45](#), [92E20](#)]
- 80A32** Chemically reacting flows [See also [92C45](#), [92E20](#)]
- 80A50** Chemistry (general) in thermodynamics and heat transfer [See mainly [92Exx](#)]
- 80A60** Radiative heat transfer
- 80A99** None of the above, but in this section

### **80Mxx Basic methods in thermodynamics and heat transfer [See also [65-XX](#)]**

- 80M10** Finite element, Galerkin and related methods applied to problems in thermodynamics and heat transfer
- 80M12** Finite volume methods applied to problems in thermodynamics and heat transfer
- 80M15** Boundary element methods applied to problems in thermodynamics and heat transfer
- 80M20** Finite difference methods applied to problems in thermodynamics and heat transfer
- 80M22** Spectral, collocation and related (meshless) methods applied to problems in thermodynamics and heat transfer
- 80M25** Other numerical methods applied to problems in thermodynamics and heat transfer
- 80M30** Variational methods applied to problems in thermodynamics and heat transfer
- 80M31** Monte Carlo methods applied to problems in thermodynamics and heat transfer
- 80M35** Asymptotic analysis for problems in thermodynamics and heat transfer
- 80M40** Homogenization for problems in thermodynamics and heat transfer
- 80M50** Optimization problems in thermodynamics and heat transfer
- 80M60** Stochastic analysis in thermodynamics and heat transfer
- 80M99** None of the above, but in this section

## **81-XX Quantum theory**

- 81-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to quantum theory
- 81-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to quantum theory
- 81-02** Research exposition (monographs, survey articles) pertaining to quantum theory
- 81-03** History of quantum theory [Consider also classification numbers pertaining to Section [01](#)]
- 81-04** Software, source code, etc. for problems pertaining to quantum theory
- 81-05** Experimental work for problems pertaining to quantum theory

- 81-06** Proceedings, conferences, collections, etc. pertaining to quantum theory
- 81-08** Computational methods for problems pertaining to quantum theory
- 81-10** Mathematical modeling or simulation for problems pertaining to quantum theory
- 81-11** Research data for problems pertaining to quantum theory

## **81Pxx Foundations, quantum information and its processing, quantum axioms, and philosophy**

- 81P05** General and philosophical questions in quantum theory
- 81P10** Logical foundations of quantum mechanics; quantum logic (quantum-theoretic aspects) [See also [03G12](#), [06C15](#)]
- 81P13** Contextuality in quantum theory
- 81P15** Quantum measurement theory, state operations, state preparations
- 81P16** Quantum state spaces, operational and probabilistic concepts
- 81P17** Quantum entropies
- 81P18** Quantum state tomography, quantum state discrimination
- 81P20** Stochastic mechanics (including stochastic electrodynamics)
- 81P40** Quantum coherence, entanglement, quantum correlations
- 81P42** Entanglement measures, concurrencies, separability criteria
- 81P43** Quantum discord
- 81P45** Quantum information, communication, networks (quantum-theoretic aspects) [See also [94A15](#), [94A17](#)]
- 81P47** Quantum channels, fidelity [See also [94A40](#)]
- 81P48** LOCC, teleportation, dense coding, remote state operations, distillation
- 81P50** Quantum state estimation, approximate cloning
- 81P55** Special bases (entangled, mutual unbiased, etc.)
- 81P65** Quantum gates
- 81P68** Quantum computation [See also [68Q09](#)] {For algorithmic aspects, see [68Q12](#)}
- 81P70** Quantum coding (general)
- 81P73** Computational stability and error-correcting codes for quantum computation and communication processing
- 81P94** Quantum cryptography (quantum-theoretic aspects) [See also [94A60](#)]
- 81P99** None of the above, but in this section

## **81Qxx General mathematical topics and methods in quantum theory**

- 81Q05** Closed and approximate solutions to the Schrödinger, Dirac, Klein-Gordon and other equations of quantum mechanics
- 81Q10** Selfadjoint operator theory in quantum theory, including spectral analysis
- 81Q12** Nonselfadjoint operator theory in quantum theory including creation and destruction operators
- 81Q15** Perturbation theories for operators and differential equations in quantum theory
- 81Q20** Semiclassical techniques, including WKB and Maslov methods applied to problems in quantum theory
- 81Q30** Feynman integrals and graphs; applications of algebraic topology and algebraic geometry [See also [14D05](#), [32S40](#)]
- 81Q35** Quantum mechanics on special spaces: manifolds, fractals, graphs, lattices [See also [81R20](#)]
- 81Q37** Quantum dots, waveguides, ratchets, etc. [See also [82D20](#), [82D77](#)]
- 81Q40** Bethe-Salpeter and other integral equations arising in quantum theory
- 81Q50** Quantum chaos [See also [37Dxx](#)]
- 81Q60** Supersymmetry and quantum mechanics
- 81Q65** Alternative quantum mechanics (including hidden variables, etc.)
- 81Q70** differential geometric methods, including holonomy, Berry and Hannay phases, Aharonov-Bohm effect, etc. in quantum theory
- 81Q80** Special quantum systems, such as solvable systems
- 81Q93** Quantum control
- 81Q99** None of the above, but in this section

## **81Rxx Groups and algebras in quantum theory**

- 81R05** Finite-dimensional groups and algebras motivated by physics and their representations [See also [20C35](#), [22E70](#)]
- 81R10** Infinite-dimensional groups and algebras motivated by physics, including Virasoro, Kac-Moody,  $W$ -algebras and other current algebras and their representations [See also [17B65](#), [17B67](#), [22E65](#), [22E67](#), [22E70](#)]
- 81R12** Groups and algebras in quantum theory and relations with integrable systems [See also [17Bxx](#), [37J35](#)]
- 81R15** Operator algebra methods applied to problems in quantum theory [See also [46Lxx](#), [81T05](#)]
- 81R20** Covariant wave equations in quantum theory, relativistic quantum mechanics [See also [81Q35](#)]
- 81R25** Spinor and twistor methods applied to problems in quantum theory [See also [32L25](#)]

- 81R30** Coherent states [See also [22E45](#)]; squeezed states in quantum theory [See also [81V80](#)]
- 81R40** Symmetry breaking in quantum theory
- 81R50** Quantum groups and related algebraic methods applied to problems in quantum theory [See also [16T20](#), [17B37](#)]
- 81R60** Noncommutative geometry in quantum theory
- 81R99** None of the above, but in this section

## **81Sxx General quantum mechanics and problems of quantization**

- 81S05** Commutation relations and statistics as related to quantum mechanics (general)
- 81S07** Uncertainty relations, also entropic
- 81S08** Canonical quantization
- 81S10** Geometry and quantization, symplectic methods [See also [53D50](#)]
- 81S20** Stochastic quantization
- 81S22** Open systems, reduced dynamics, master equations, decoherence [See also [82C31](#)]
- 81S25** Quantum stochastic calculus
- 81S30** Phase-space methods including Wigner distributions, etc. applied to problems in quantum mechanics
- 81S40** Path integrals in quantum mechanics [See also [58D30](#), [81Q30](#), [81T18](#)]
- 81S99** None of the above, but in this section

## **81Txx Quantum field theory; related classical field theories [See also [70Sxx](#)]**

- 81T05** Axiomatic quantum field theory; operator algebras
- 81T08** Constructive quantum field theory
- 81T10** Model quantum field theories
- 81T11** Higher spin theories
- 81T12** Effective quantum field theories
- 81T13** Yang-Mills and other gauge theories in quantum field theory [See also [53C07](#), [58E15](#)]
- 81T15** Perturbative methods of renormalization applied to problems in quantum field theory
- 81T16** Nonperturbative methods of renormalization applied to problems in quantum field theory
- 81T17** Renormalization group methods applied to problems in quantum field theory
- 81T18** Feynman diagrams
- 81T20** Quantum field theory on curved space or space-time backgrounds
- 81T25** Quantum field theory on lattices
- 81T27** Continuum limits in quantum field theory
- 81T28** Thermal quantum field theory [See also [82B30](#)]

- 81T30** String and superstring theories; other extended objects (e.g., branes) in quantum field theory [See also [83E30](#)]
- 81T32** Matrix models and tensor models for quantum field theory
- 81T33** Dimensional compactification in quantum field theory
- 81T35** Correspondence, duality, holography (ADS/CFT, gauge/gravity, etc.) [See also [83E05](#)]
- 81T40** Two-dimensional field theories, conformal field theories, etc. in quantum mechanics
- 81T45** Topological field theories in quantum mechanics [See also [57R56](#), [58Dxx](#)]
- 81T50** Anomalies in quantum field theory
- 81T55** Casimir effect in quantum field theory
- 81T60** Supersymmetric field theories in quantum mechanics
- 81T70** Quantization in field theory; cohomological methods [See also [58D29](#)]
- 81T75** Noncommutative geometry methods in quantum field theory [See also [46L85](#), [46L87](#), [58B34](#)]
- 81T99** None of the above, but in this section

## **81Uxx Quantum scattering theory [See also [34A55](#), [34L25](#), [34L40](#), [35P25](#), [47A40](#)]**

- 81U05** 2-body potential quantum scattering theory {For WKB methods, see also [34E20](#)}
- 81U10**  $n$ -body potential quantum scattering theory
- 81U15** Exactly and quasi-solvable systems arising in quantum theory
- 81U20**  $S$ -matrix theory, etc. in quantum theory
- 81U24** Resonances in quantum scattering theory
- 81U26** Tunneling in quantum theory
- 81U30** Dispersion theory, dispersion relations arising in quantum theory
- 81U35** Inelastic and multichannel quantum scattering
- 81U40** Inverse scattering problems in quantum theory
- 81U90** Particle decays in scattering
- 81U99** None of the above, but in this section

## **81Vxx Applications of quantum theory to specific physical systems**

- 81V05** Strong interaction, including quantum chromodynamics
- 81V10** Electromagnetic interaction; quantum electrodynamics
- 81V15** Weak interaction in quantum theory
- 81V17** Gravitational interaction in quantum theory [See also [83Cxx](#), [83Exx](#)]
- 81V19** Other fundamental interactions in quantum theory
- 81V22** Unified quantum theories

- 81V25** Other elementary particle theory in quantum theory
- 81V27** Anyons
- 81V35** Nuclear physics
- 81V45** Atomic physics
- 81V55** Molecular physics [See also [92E10](#)]
- 81V60** Mono-, di- and multipole moments (EM and other), gyromagnetic relations
- 81V65** Quantum dots as quasi particles [See also [82D20](#)]
- 81V70** Many-body theory; quantum Hall effect
- 81V72** Particle exchange symmetries in quantum theory (general)
- 81V73** Bosonic systems in quantum theory
- 81V74** Fermionic systems in quantum theory
- 81V80** Quantum optics
- 81V99** None of the above, but in this section

## **82-XX Statistical mechanics, structure of matter**

- 82-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to statistical mechanics
  - 82-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to statistical mechanics
  - 82-02** Research exposition (monographs, survey articles) pertaining to statistical mechanics
  - 82-03** History of statistical mechanics [Consider also classification numbers pertaining to [Section 01](#)]
  - 82-04** Software, source code, etc. for problems pertaining to statistical mechanics
  - 82-05** Experimental work for problems pertaining to statistical mechanics
  - 82-06** Proceedings, conferences, collections, etc. pertaining to statistical mechanics
  - 82-10** Mathematical modeling or simulation for problems pertaining to statistical mechanics
  - 82-11** Research data for problems pertaining to statistical mechanics
- 82Bxx Equilibrium statistical mechanics**
- 82B03** Foundations of equilibrium statistical mechanics
  - 82B05** Classical equilibrium statistical mechanics (general)
  - 82B10** Quantum equilibrium statistical mechanics (general)
  - 82B20** Lattice systems (Ising, dimer, Potts, etc.) and systems on graphs arising in equilibrium statistical mechanics
  - 82B21** Continuum models (systems of particles, etc.) arising in equilibrium statistical mechanics
  - 82B23** Exactly solvable models; Bethe ansatz
  - 82B24** Interface problems; diffusion-limited aggregation arising in equilibrium statistical mechanics
  - 82B26** Phase transitions (general) in equilibrium statistical mechanics
  - 82B27** Critical phenomena in equilibrium statistical mechanics
  - 82B28** Renormalization group methods in equilibrium statistical mechanics [See also [81T17](#)]
  - 82B30** Statistical thermodynamics [See also [80-XX](#)]
  - 82B31** Stochastic methods applied to problems in equilibrium statistical mechanics
  - 82B35** Irreversible thermodynamics, including Onsager-Machlup theory [See also [92E20](#)]
  - 82B40** Kinetic theory of gases in equilibrium statistical mechanics
  - 82B41** Random walks, random surfaces, lattice animals, etc. in equilibrium statistical mechanics [See also [60G50](#), [82C41](#)]
  - 82B43** Percolation [See also [60K35](#)]
  - 82B44** Disordered systems (random Ising models, random Schrödinger operators, etc.) in equilibrium statistical mechanics
  - 82B99** None of the above, but in this section
- 82Cxx Time-dependent statistical mechanics (dynamic and nonequilibrium)**
- 82C03** Foundations of time-dependent statistical mechanics
  - 82C05** Classical dynamic and nonequilibrium statistical mechanics (general)
  - 82C10** Quantum dynamics and nonequilibrium statistical mechanics (general)
  - 82C20** Dynamic lattice systems (kinetic Ising, etc.) and systems on graphs in time-dependent statistical mechanics
  - 82C21** Dynamic continuum models (systems of particles, etc.) in time-dependent statistical mechanics
  - 82C22** Interacting particle systems in time-dependent statistical mechanics [See also [60K35](#)]
  - 82C23** Exactly solvable dynamic models in time-dependent statistical mechanics [See also [37K60](#)]
  - 82C24** Interface problems; diffusion-limited aggregation in time-dependent statistical mechanics
  - 82C26** Dynamic and nonequilibrium phase transitions (general) in statistical mechanics
  - 82C27** Dynamic critical phenomena in statistical mechanics
  - 82C28** Dynamic renormalization group methods applied to problems in time-dependent statistical mechanics [See also [81T17](#)]
  - 82C31** Stochastic methods (Fokker-Planck, Langevin, etc.) applied to problems in time-dependent statistical mechanics [See also [60H10](#)]
  - 82C32** Neural nets applied to problems in time-dependent statistical mechanics [See also [68T05](#), [91E40](#), [92B20](#)]

- 82C35** Irreversible thermodynamics, including Onsager-Machlup theory
- 82C40** Kinetic theory of gases in time-dependent statistical mechanics
- 82C41** Dynamics of random walks, random surfaces, lattice animals, etc. in time-dependent statistical mechanics [See also [60G50](#)]
- 82C43** Time-dependent percolation in statistical mechanics [See also [60K35](#)]
- 82C44** Dynamics of disordered systems (random Ising systems, etc.) in time-dependent statistical mechanics
- 82C70** Transport processes in time-dependent statistical mechanics
- 82C99** None of the above, but in this section

## **82Dxx Applications of statistical mechanics to specific types of physical systems**

- 82D03** Statistical mechanical studies in condensed matter (general)
- 82D05** Statistical mechanical studies of gases
- 82D10** Statistical mechanical studies of plasmas
- 82D15** Statistical mechanical studies of liquids
- 82D20** Statistical mechanical studies of solids
- 82D25** Statistical mechanical studies of crystals {For crystallographic group theory, see [20H15](#)}
- 82D30** Statistical mechanical studies of random media, disordered materials (including liquid crystals and spin glasses)
- 82D35** Statistical mechanical studies of metals
- 82D37** Statistical mechanical studies of semiconductors
- 82D40** Statistical mechanical studies of magnetic materials
- 82D45** Statistical mechanical studies of ferroelectrics
- 82D50** Statistical mechanical studies of superfluids
- 82D55** Statistical mechanical studies of superconductors
- 82D60** Statistical mechanical studies of polymers
- 82D75** Nuclear reactor theory; neutron transport
- 82D77** Quantum waveguides, quantum wires [See also [78A50](#)]
- 82D80** Statistical mechanical studies of nanostructures and nanoparticles
- 82D99** None of the above, but in this section

## **82Mxx Basic methods in statistical mechanics [See also [65-XX](#)]**

- 82M10** Finite element, Galerkin and related methods applied to problems in statistical mechanics
- 82M12** Finite volume methods applied to problems in statistical mechanics

- 82M15** Boundary element methods applied to problems in statistical mechanics
- 82M20** Finite difference methods applied to problems in statistical mechanics
- 82M22** Spectral, collocation and related (meshless) methods applied to problems in statistical mechanics
- 82M25** Other numerical methods applied to problems in statistical mechanics
- 82M30** Variational methods applied to problems in statistical mechanics
- 82M31** Monte Carlo methods applied to problems in statistical mechanics [See also [65C05](#)]
- 82M36** Computational density functional analysis in statistical mechanics
- 82M37** Computational molecular dynamics in statistical mechanics
- 82M60** Stochastic analysis in statistical mechanics [See also [65C35](#)]
- 82M99** None of the above, but in this section

## **83-XX Relativity and gravitational theory**

- 83-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to relativity and gravitational theory
- 83-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to relativity and gravitational theory
- 83-02** Research exposition (monographs, survey articles) pertaining to relativity and gravitational theory
- 83-03** History of relativity and gravitational theory [Consider also classification numbers pertaining to [Section 01](#)]
- 83-04** Software, source code, etc. for problems pertaining to relativity and gravitational theory
- 83-05** Experimental work for problems pertaining to relativity and gravitational theory
- 83-06** Proceedings, conferences, collections, etc. pertaining to relativity and gravitational theory
- 83-08** Computational methods for problems pertaining to relativity and gravitational theory
- 83-10** Mathematical modeling or simulation for problems pertaining to relativity and gravitational theory
- 83-11** Research data for problems pertaining to relativity and gravitational theory

## **83Axx Special relativity**

- 83A05** Special relativity
- 83A99** None of the above, but in this section



## **83Bxx Observational and experimental questions in relativity and gravitational theory**

- 83B05** Observational and experimental questions in relativity and gravitational theory
- 83B99** None of the above, but in this section

## **83Cxx General relativity**

- 83C05** Einstein's equations (general structure, canonical formalism, Cauchy problems)
- 83C10** Equations of motion in general relativity and gravitational theory
- 83C15** Exact solutions to problems in general relativity and gravitational theory
- 83C20** Classes of solutions; algebraically special solutions, metrics with symmetries for problems in general relativity and gravitational theory
- 83C22** Einstein-Maxwell equations
- 83C25** Approximation procedures, weak fields in general relativity and gravitational theory
- 83C27** Lattice gravity, Regge calculus and other discrete methods in general relativity and gravitational theory
- 83C30** Asymptotic procedures (radiation, news functions,  $\mathcal{H}$ -spaces, etc.) in general relativity and gravitational theory
- 83C35** Gravitational waves
- 83C40** Gravitational energy and conservation laws; groups of motions
- 83C45** Quantization of the gravitational field
- 83C47** Methods of quantum field theory in general relativity and gravitational theory [See also [81T20](#)]
- 83C50** Electromagnetic fields in general relativity and gravitational theory
- 83C55** Macroscopic interaction of the gravitational field with matter (hydrodynamics, etc.)
- 83C56** Dark matter and dark energy
- 83C57** Black holes
- 83C60** Spinor and twistor methods in general relativity and gravitational theory; Newman-Penrose formalism
- 83C65** Methods of noncommutative geometry in general relativity [See also [58B34](#)]
- 83C75** Space-time singularities, cosmic censorship, etc.
- 83C80** Analogues of general relativity in lower dimensions
- 83C99** None of the above, but in this section

## **83Dxx Relativistic gravitational theories other than Einstein's, including asymmetric field theories**

- 83D05** Relativistic gravitational theories other than Einstein's, including asymmetric field theories
- 83D99** None of the above, but in this section

## **83Exx Unified, higher-dimensional and super field theories**

- 83E05** Geometrodynamics and the holographic principle [See also [81T35](#)]
- 83E15** Kaluza-Klein and other higher-dimensional theories
- 83E30** String and superstring theories in gravitational theory [See also [81T30](#)]
- 83E50** Supergravity
- 83E99** None of the above, but in this section

## **83Fxx Cosmology**

- 83F05** Cosmology
- 83F99** None of the above, but in this section

## **85-XX Astronomy and astrophysics {For celestial mechanics, see [70F15](#)}**

- 85-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to astronomy and astrophysics
- 85-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to astronomy and astrophysics
- 85-02** Research exposition (monographs, survey articles) pertaining to astronomy and astrophysics
- 85-03** History of astronomy and astrophysics [Consider also classification numbers pertaining to [Section 01](#)]
- 85-04** Software, source code, etc. for problems pertaining to astronomy and astrophysics
- 85-05** Experimental work for problems pertaining to astronomy and astrophysics
- 85-06** Proceedings, conferences, collections, etc. pertaining to astronomy and astrophysics
- 85-08** Computational methods for problems pertaining to astronomy and astrophysics
- 85-10** Mathematical modeling or simulation for problems pertaining to astronomy and astrophysics
- 85-11** Research data for problems pertaining to astronomy and astrophysics

## **85Axx Astronomy and astrophysics {For celestial mechanics, see 70F15}**

- 85A04** General questions in astronomy and astrophysics
- 85A05** Galactic and stellar dynamics
- 85A15** Galactic and stellar structure
- 85A20** Planetary atmospheres
- 85A25** Radiative transfer in astronomy and astrophysics
- 85A30** Hydrodynamic and hydromagnetic problems in astronomy and astrophysics [See also 76Y05]
- 85A35** Statistical astronomy
- 85A40** Cosmology {For relativistic cosmology, see 83F05}
- 85A99** None of the above, but in this section

## **86-XX Geophysics [See also 76U05, 76V05]**

- 86-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to geophysics
- 86-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to geophysics
- 86-02** Research exposition (monographs, survey articles) pertaining to geophysics
- 86-03** History of geophysics [Consider also classification numbers pertaining to Section 01]
- 86-04** Software, source code, etc. for problems pertaining to geophysics
- 86-05** Experimental work for problems pertaining to geophysics
- 86-06** Proceedings, conferences, collections, etc. pertaining to geophysics
- 86-08** Computational methods for problems pertaining to geophysics
- 86-10** Mathematical modeling or simulation for problems pertaining to geophysics
- 86-11** Research data for problems pertaining to geophysics

## **86Axx Geophysics [See also 76U05, 76V05]**

- 86A04** General questions in geophysics
- 86A05** Hydrology, hydrography, oceanography [See also 76Bxx, 76E20, 76Q05, 76Rxx, 76U05]
- 86A08** Climate science and climate modeling
- 86A10** Meteorology and atmospheric physics [See also 76Bxx, 76E20, 76N15, 76Q05, 76Rxx, 76U05]
- 86A15** Seismology (including tsunami modeling), earthquakes
- 86A20** Potentials, prospecting
- 86A22** Inverse problems in geophysics [See also 35R30]

**86A25** Geo-electricity and geomagnetism [See also 76W05, 78A25]

- 86A30** Geodesy, mapping problems
- 86A32** Geostatistics
- 86A40** Glaciology
- 86A60** Geological problems
- 86A70** Vulcanology; magma and lava flow
- 86A99** None of the above, but in this section

## **90-XX Operations research, mathematical programming**

- 90-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to operations research and mathematical programming
- 90-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to operations research and mathematical programming
- 90-02** Research exposition (monographs, survey articles) pertaining to operations research and mathematical programming
- 90-03** History of operations research and mathematical programming [Consider also classification numbers pertaining to Section 01]
- 90-04** Software, source code, etc. for problems pertaining to operations research and mathematical programming
- 90-05** Experimental work for problems pertaining to operations research and mathematical programming
- 90-06** Proceedings, conferences, collections, etc. pertaining to operations research and mathematical programming
- 90-08** Computational methods for problems pertaining to operations research and mathematical programming
- 90-10** Mathematical modeling or simulation for problems pertaining to operations research and mathematical programming
- 90-11** Research data for problems pertaining to operations research and mathematical programming

## **90Bxx Operations research and management science**

- 90B05** Inventory, storage, reservoirs
- 90B06** Transportation, logistics and supply chain management
- 90B10** Deterministic network models in operations research {For network control, see 93B70}
- 90B15** Stochastic network models in operations research {For network control, see 93B70}
- 90B18** Communication networks in operations research [See also 68M10, 68M12, 68M18, 94A05] {For networks as computational models, see 68Q06}
- 90B20** Traffic problems in operations research

- 90B22** Queues and service in operations research [See also [60K25](#), [68M20](#)]
- 90B25** Reliability, availability, maintenance, inspection in operations research [See also [60K10](#), [62N05](#)]
- 90B30** Production models
- 90B35** Deterministic scheduling theory in operations research [See also [68M20](#)]
- 90B36** Stochastic scheduling theory in operations research [See also [68M20](#)]
- 90B40** Search theory
- 90B50** Management decision making, including multiple objectives [See also [90C29](#), [90C31](#), [91A35](#), [91B06](#)]
- 90B60** Marketing, advertising [See also [91B60](#)]
- 90B70** Theory of organizations, manpower planning in operations research [See also [91D35](#)]
- 90B80** Discrete location and assignment [See also [90C10](#)]
- 90B85** Continuous location
- 90B90** Case-oriented studies in operations research
- 90B99** None of the above, but in this section
- 90Cxx** **Mathematical programming** [See also [49Mxx](#), [65Kxx](#)]
- 90C05** Linear programming
- 90C06** Large-scale problems in mathematical programming
- 90C08** Special problems of linear programming (transportation, multi-index, data envelopment analysis, etc.)
- 90C09** Boolean programming
- 90C10** Integer programming
- 90C11** Mixed integer programming
- 90C15** Stochastic programming
- 90C17** Robustness in mathematical programming
- 90C20** Quadratic programming
- 90C22** Semidefinite programming
- 90C23** Polynomial optimization
- 90C24** Tropical optimization (e.g., max-plus optimization)
- 90C25** Convex programming
- 90C26** Nonconvex programming, global optimization
- 90C27** Combinatorial optimization
- 90C29** Multi-objective and goal programming
- 90C30** Nonlinear programming
- 90C31** Sensitivity, stability, parametric optimization
- 90C32** Fractional programming
- 90C33** Complementarity and equilibrium problems and variational inequalities (finite dimensions) (aspects of mathematical programming)
- 90C34** Semi-infinite programming
- 90C35** Programming involving graphs or networks [See also [90C27](#)]
- 90C39** Dynamic programming [See also [49L20](#)]
- 90C40** Markov and semi-Markov decision processes
- 90C46** Optimality conditions and duality in mathematical programming [See also [49N15](#)]
- 90C47** Minimax problems in mathematical programming [See also [49K35](#)]
- 90C48** Programming in abstract spaces
- 90C49** Extreme-point and pivoting methods
- 90C51** Interior-point methods
- 90C52** Methods of reduced gradient type
- 90C53** Methods of quasi-Newton type
- 90C55** Methods of successive quadratic programming type
- 90C56** Derivative-free methods and methods using generalized derivatives [See also [49J52](#)]
- 90C57** Polyhedral combinatorics, branch-and-bound, branch-and-cut
- 90C59** Approximation methods and heuristics in mathematical programming
- 90C60** Abstract computational complexity for mathematical programming problems [See also [68Q25](#)]
- 90C70** Fuzzy and other nonstochastic uncertainty mathematical programming
- 90C90** Applications of mathematical programming
- 90C99** None of the above, but in this section
- 91-XX** **Game theory, economics, finance, and other social and behavioral sciences**
- 91-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to game theory, economics, and finance
- 91-01** exposition (textbooks, tutorial papers, etc.) pertaining to game theory, economics, and finance
- 91-02** Research exposition (monographs, survey articles) pertaining to game theory, economics, and finance
- 91-03** History of game theory, economics, and finance [Consider also classification numbers pertaining to Section [01](#)]
- 91-04** Software, source code, etc. for problems pertaining to game theory, economics, and finance
- 91-05** Experimental work for problems pertaining to game theory, economics, and finance
- 91-06** Proceedings, conferences, collections, etc. pertaining to game theory, economics, and finance
- 91-08** Computational methods for problems pertaining to game theory, economics, and finance

- 91-10** Mathematical modeling or simulation for problems pertaining to game theory, economics, and finance
- 91-11** Research data for problems pertaining to game theory, economics, and finance

## **91Axx Game theory**

- 91A05** 2-person games
- 91A06**  $n$ -person games,  $n > 2$
- 91A07** Games with infinitely many players
- 91A10** Noncooperative games
- 91A11** Equilibrium refinements
- 91A12** Cooperative games
- 91A14** Potential and congestion games
- 91A15** Stochastic games, stochastic differential games
- 91A16** Mean field games (aspects of game theory) [See also [35Q89](#), [49N80](#)]
- 91A18** Games in extensive form
- 91A20** Multistage and repeated games
- 91A22** Evolutionary games
- 91A23** Differential games (aspects of game theory) [See also [49N70](#)]
- 91A24** Positional games (pursuit and evasion, etc.) [See also [49N75](#)]
- 91A25** Dynamic games
- 91A26** Rationality and learning in game theory
- 91A27** Games with incomplete information, Bayesian games
- 91A28** Signaling and communication in game theory
- 91A30** Utility theory for games [See also [91B16](#)]
- 91A35** Decision theory for games [See also [62Cxx](#), [90B50](#), [91B06](#)]
- 91A40** Other game-theoretic models
- 91A43** Games involving graphs {For games on graphs, see [05C57](#)}
- 91A44** Games involving topology, set theory, or logic
- 91A46** Combinatorial games
- 91A50** Discrete-time games
- 91A55** Games of timing
- 91A60** Probabilistic games; gambling [See also [60G40](#)]
- 91A65** Hierarchical games (including Stackelberg games)
- 91A68** Algorithmic game theory and complexity [See also [68Qxx](#), [68Wxx](#)]
- 91A70** Spaces of games
- 91A80** Applications of game theory
- 91A81** Quantum games
- 91A86** Game theory and fuzziness
- 91A90** Experimental studies
- 91A99** None of the above, but in this section

## **91Bxx Mathematical economics {For econometrics, see [62P20](#)}**

- 91B02** Fundamental topics (basic mathematics, methodology; applicable to economics in general)
- 91B03** Mechanism design theory
- 91B05** Risk models (general) {For actuarial and financial risk, see [91Gxx](#)}
- 91B06** Decision theory [See also [62Cxx](#), [90B50](#), [91A35](#)]
- 91B08** Individual preferences
- 91B10** Group preferences
- 91B12** Voting theory
- 91B14** Social choice
- 91B15** Welfare economics
- 91B16** Utility theory [See also [91A30](#)]
- 91B18** Public goods
- 91B24** Microeconomic theory (price theory and economic markets)
- 91B26** Auctions, bargaining, bidding and selling, and other market models
- 91B32** Resource and cost allocation (including fair division, apportionment, etc.)
- 91B38** Production theory, theory of the firm
- 91B39** Labor markets
- 91B41** Contract theory (moral hazard, adverse selection)
- 91B42** Consumer behavior, demand theory
- 91B43** Principal-agent models
- 91B44** Economics of information
- 91B50** General equilibrium theory
- 91B51** Dynamic stochastic general equilibrium theory
- 91B52** Special types of economic equilibria
- 91B54** Special types of economic markets (including Cournot, Bertrand)
- 91B55** Economic dynamics
- 91B60** Trade models
- 91B62** Economic growth models
- 91B64** Macroeconomic theory (monetary models, models of taxation)
- 91B66** Multisectoral models in economics
- 91B68** Matching models
- 91B69** Heterogeneous agent models
- 91B70** Stochastic models in economics
- 91B72** Spatial models in economics [See also [91D25](#)]
- 91B74** Economic models of real-world systems (e.g., electricity markets, etc.)
- 91B76** Environmental economics (natural resource models, harvesting, pollution, etc.)

**91B80** Applications of statistical and quantum mechanics to economics (econophysics)

**91B82** Statistical methods; economic indices and measures [See also [62P20](#)]

**91B84** Economic time series analysis {For statistical theory of time series, see [62M10](#)}

**91B86** Mathematical economics and fuzziness

**91B99** None of the above, but in this section

### **91Cxx Social and behavioral sciences: general topics {For statistics, see [62P25](#)}**

**91C05** Measurement theory in the social and behavioral sciences

**91C15** One- and multidimensional scaling in the social and behavioral sciences

**91C20** Clustering in the social and behavioral sciences [See also [62H30](#)]

**91C99** None of the above, but in this section

### **91Dxx Mathematical sociology (including anthropology)**

**91D10** Models of societies, social and urban evolution

**91D15** Social learning

**91D20** Mathematical geography and demography

**91D25** Spatial models in sociology [See also [91B72](#)]

**91D30** Social networks; opinion dynamics

**91D35** Manpower systems in sociology [See also [90B70](#), [91B39](#)]

**91D99** None of the above, but in this section

### **91Exx Mathematical psychology {For psychometrics, see [62P15](#)}**

**91E10** Cognitive psychology

**91E30** Psychophysics and psychophysiology; perception

**91E40** Memory and learning in psychology [See also [68T05](#)]

**91E45** Measurement and performance in psychology

**91E99** None of the above, but in this section

### **91Fxx Other social and behavioral sciences (mathematical treatment)**

**91F10** History, political science

**91F20** Linguistics [See also [03B65](#), [68T50](#)]

**91F99** None of the above, but in this section

### **91Gxx Actuarial science and mathematical finance {For statistics, see [62P05](#)}**

**91G05** Actuarial mathematics

**91G10** Portfolio theory

**91G15** Financial markets

**91G20** Derivative securities (option pricing, hedging, etc.)

**91G30** Interest rates, asset pricing, etc. (stochastic models)

**91G40** Credit risk

**91G45** Financial networks (including contagion, systemic risk, regulation)

**91G50** Corporate finance (dividends, real options, etc.)

**91G60** Numerical methods (including Monte Carlo methods)

**91G70** Statistical methods; risk measures [See also [62P05](#), [62P20](#)]

**91G80** Financial applications of other theories [See also [35Q91](#), [37N40](#), [49N90](#), [60J70](#), [60K10](#), [60H30](#), [93E20](#)]

**91G99** None of the above, but in this section

### **92-XX Biology and other natural sciences**

**92-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to biology

**92-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to biology

**92-02** Research exposition (monographs, survey articles) pertaining to biology

**92-03** History of biology [Consider also classification numbers pertaining to Section [01](#)]

**92-04** Software, source code, etc. for problems pertaining to biology

**92-05** Experimental work for problems pertaining to biology

**92-06** Proceedings, conferences, collections, etc. pertaining to biology

**92-08** Computational methods for problems pertaining to biology

**92-10** Mathematical modeling or simulation for problems pertaining to biology

**92-11** Research data for problems pertaining to biology

### **92Bxx Mathematical biology in general**

**92B05** General biology and biomathematics

**92B10** Taxonomy, cladistics, statistics in mathematical biology

**92B15** General biostatistics [See also [62P10](#)]

**92B20** Neural networks for/in biological studies, artificial life and related topics [See also [68T05](#), [82C32](#), [94Cxx](#)]

**92B25** Biological rhythms and synchronization

**92B99** None of the above, but in this section



## 92Cxx Physiological, cellular and medical topics

- 92C05 Biophysics
- 92C10 Biomechanics [See also 74L15]
- 92C15 Developmental biology, pattern formation
- 92C17 Cell movement (chemotaxis, etc.)
- 92C20 Neural biology
- 92C30 Physiology (general)
- 92C32 Pathology, pathophysiology
- 92C35 Physiological flow [See also 76Z05]
- 92C37 Cell biology
- 92C40 Biochemistry, molecular biology
- 92C42 Systems biology, networks
- 92C45 Kinetics in biochemical problems (pharmacokinetics, enzyme kinetics, etc.) [See also 80A30]
- 92C47 Biosensors (not for medical applications)
- 92C50 Medical applications (general)
- 92C55 Biomedical imaging and signal processing [See also 44A12, 65R10, 94A08, 94A12]
- 92C60 Medical epidemiology {For theoretical aspects, see 92D30}
- 92C70 Microbiology
- 92C75 Biotechnology
- 92C80 Plant biology
- 92C99 None of the above, but in this section

## 92Dxx Genetics and population dynamics

- 92D10 Genetics and epigenetics {For genetic algebras, see 17D92}
- 92D15 Problems related to evolution
- 92D20 Protein sequences, DNA sequences
- 92D25 Population dynamics (general)
- 92D30 Epidemiology {For medical applications, see 92C60}
- 92D40 Ecology
- 92D45 Pest management
- 92D50 Animal behavior
- 92D99 None of the above, but in this section

## 92Exx Chemistry {For biochemistry, see 92C40}

- 92E10 Molecular structure (graph-theoretic methods, methods of differential topology, etc.)
- 92E20 Classical flows, reactions, etc. in chemistry [See also 80A30, 80A32]
- 92E99 None of the above, but in this section

## 92Fxx Other natural sciences (mathematical treatment)

- 92F05 Other natural sciences (mathematical treatment)
- 92F99 None of the above, but in this section

## 93-XX Systems theory; control {For optimal control, see 49-XX}

- 93-00 General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to systems and control theory
- 93-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to systems and control theory
- 93-02 Research exposition (monographs, survey articles) pertaining to systems and control theory
- 93-03 History of systems and control theory [Consider also classification numbers pertaining to Section 01]
- 93-04 Software, source code, etc. for problems pertaining to systems and control theory
- 93-05 Experimental work for problems pertaining to systems and control theory
- 93-06 Proceedings, conferences, collections, etc. pertaining to systems and control theory
- 93-08 Computational methods for problems pertaining to systems and control theory
- 93-10 Mathematical modeling or simulation for problems pertaining to systems and control theory
- 93-11 Research data for problems pertaining to systems and control theory

## 93Axx General systems theory

- 93A05 Axiomatic systems theory
- 93A10 General systems
- 93A13 Hierarchical systems
- 93A14 Decentralized systems
- 93A15 Large-scale systems
- 93A16 Multi-agent systems
- 93A99 None of the above, but in this section

## 93Bxx Controllability, observability, and system structure

- 93B03 Attainable sets, reachability
- 93B05 Controllability
- 93B07 Observability
- 93B10 Canonical structure
- 93B11 System structure simplification
- 93B12 Variable structure systems
- 93B15 Realizations from input-output data
- 93B17 Transformations
- 93B18 Linearizations
- 93B20 Minimal systems representations
- 93B24 Topological methods
- 93B25 Algebraic methods
- 93B27 Geometric methods
- 93B28 Operator-theoretic methods [See also [47A48](#), [47A57](#), [47B35](#), [47N70](#)]
- 93B30 System identification
- 93B35 Sensitivity (robustness)
- 93B36  $H^\infty$ -control
- 93B45 Model predictive control
- 93B47 Iterative learning control
- 93B50 Synthesis problems
- 93B51 Design techniques (robust design, computer-aided design, etc.)
- 93B52 Feedback control
- 93B53 Observers
- 93B55 Pole and zero placement problems
- 93B60 Eigenvalue problems
- 93B70 Networked control
- 93B99 None of the above, but in this section

## 93Cxx Model systems in control theory

- 93C05 Linear systems in control theory
- 93C10 Nonlinear systems in control theory
- 93C15 Control/observation systems governed by ordinary differential equations [See also [34H05](#)]
- 93C20 Control/observation systems governed by partial differential equations
- 93C23 Control/observation systems governed by functional-differential equations [See also [34K35](#)]
- 93C25 Control/observation systems in abstract spaces
- 93C27 Impulsive control/observation systems
- 93C28 Positive control/observation systems
- 93C29 Boolean control/observation systems

93C30 Control/observation systems governed by functional relations other than differential equations (such as hybrid and switching systems)

- 93C35 Multivariable systems, multidimensional control systems
- 93C40 Adaptive control/observation systems
- 93C41 Control/observation systems with incomplete information
- 93C42 Fuzzy control/observation systems
- 93C50 Delay control/observation systems
- 93C55 Discrete-time control/observation systems
- 93C57 Sampled-data control/observation systems
- 93C62 Digital control/observation systems
- 93C65 Discrete event control/observation systems
- 93C70 Time-scale analysis and singular perturbations in control/observation systems
- 93C73 Perturbations in control/observation systems
- 93C80 Frequency-response methods in control theory
- 93C83 Control/observation systems involving computers (process control, etc.)
- 93C85 Automated systems (robots, etc.) in control theory [See also [68T40](#), [70B15](#), [70Q05](#)]
- 93C95 Application models in control theory
- 93C99 None of the above, but in this section

## 93Dxx Stability of control systems

- 93D05 Lyapunov and other classical stabilities (Lagrange, Poisson,  $L^p$ ,  $l^p$ , etc.) in control theory
- 93D09 Robust stability
- 93D10 Popov-type stability of feedback systems
- 93D15 Stabilization of systems by feedback
- 93D20 Asymptotic stability in control theory
- 93D21 Adaptive or robust stabilization
- 93D22 Exponential stability
- 93D25 Input-output approaches in control theory
- 93D30 Lyapunov and storage functions
- 93D40 Finite-time stability
- 93D50 Consensus
- 93D99 None of the above, but in this section

## 93Exx Stochastic systems and control

- 93E03 Stochastic systems in control theory (general)
- 93E10 Estimation and detection in stochastic control theory [See also [60G35](#)]
- 93E11 Filtering in stochastic control theory [See also [60G35](#)]
- 93E12 Identification in stochastic control theory
- 93E14 Data smoothing in stochastic control theory

- 93E15** Stochastic stability in control theory
- 93E20** Optimal stochastic control [See also [49J55](#), [49K45](#)]
- 93E24** Least squares and related methods for stochastic control systems
- 93E35** Stochastic learning and adaptive control
- 93E99** None of the above, but in this section

## 94-XX Information and communication theory, circuits

- 94-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to information and communication theory
- 94-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to information and communication theory
- 94-02** Research exposition (monographs, survey articles) pertaining to information and communication theory
- 94-03** History of information and communication theory [Consider also classification numbers pertaining to Section [01](#)]
- 94-04** Software, source code, etc. for problems pertaining to information and communication theory
- 94-05** Experimental work for problems pertaining to information and communication theory
- 94-06** Proceedings, conferences, collections, etc. pertaining to information and communication theory
- 94-08** Computational methods for problems pertaining to information and communication theory
- 94-10** Mathematical modeling or simulation for problems pertaining to information and communication theory
- 94-11** Research data for problems pertaining to information and communication theory

### 94Axx Communication, information

- 94A05** Communication theory [See also [60G35](#), [90B18](#)]
- 94A08** Image processing (compression, reconstruction, etc.) in information and communication theory [See also [68U10](#)]
- 94A11** Application of orthogonal and other special functions
- 94A12** Signal theory (characterization, reconstruction, filtering, etc.)
- 94A13** Detection theory in information and communication theory
- 94A14** Modulation and demodulation in information and communication theory
- 94A15** Information theory (general) [See also [62B10](#), [81P45](#)]
- 94A16** Informational aspects of data analysis and big data [See also [62R07](#), [68T09](#)] {For homological aspects, see [55N31](#)}

- 94A17** Measures of information, entropy
- 94A20** Sampling theory in information and communication theory
- 94A24** Coding theorems (Shannon theory)
- 94A29** Source coding [See also [68P30](#)]
- 94A34** Rate-distortion theory in information and communication theory
- 94A40** Channel models (including quantum) in information and communication theory [See also [81P47](#)]
- 94A45** Prefix, length-variable, comma-free codes [See also [20M35](#), [68Q45](#)]
- 94A50** Theory of questionnaires
- 94A55** Shift register sequences and sequences over finite alphabets in information and communication theory
- 94A60** Cryptography [See also [11T71](#), [14G50](#), [68P25](#), [81P94](#)]
- 94A62** Authentication, digital signatures and secret sharing [See also [81P94](#)]
- 94A99** None of the above, but in this section

### 94Bxx Theory of error-correcting codes and error-detecting codes

- 94B05** Linear codes, general
- 94B10** Convolutional codes
- 94B12** Combined modulation schemes (including trellis codes) in coding theory
- 94B15** Cyclic codes
- 94B20** Burst-correcting codes
- 94B25** Combinatorial codes
- 94B27** Geometric methods (including applications of algebraic geometry) applied to coding theory [See also [11T71](#), [14G50](#)]
- 94B30** Majority codes
- 94B35** Decoding
- 94B40** Arithmetic codes [See also [11T71](#), [14G50](#)]
- 94B50** Synchronization error-correcting codes
- 94B60** Other types of codes
- 94B65** Bounds on codes
- 94B70** Error probability in coding theory
- 94B75** Applications of the theory of convex sets and geometry of numbers (covering radius, etc.) to coding theory [See also [11H31](#), [11H71](#)]
- 94B99** None of the above, but in this section

## **94Cxx Circuits, networks [See also 68Q06]**

- 94C05** Analytic circuit theory
- 94C11** Switching theory, applications of Boolean algebras to circuits and networks
- 94C12** Fault detection; testing in circuits and networks
- 94C15** Applications of graph theory to circuits and networks [See also 05Cxx, 68R10]
- 94C30** Applications of design theory to circuits and networks [See also 05Bxx]
- 94C60** Circuits in qualitative investigation and simulation of models
- 94C99** None of the above, but in this section

## **94Dxx Miscellaneous topics in information and communication theory**

- 94D05** Fuzzy sets and logic (in connection with information, communication, or circuits theory) [See also 03B52, 03E72, 28E10]
- 94D10** Boolean functions [See also 06E30] {For connections with circuits and networks, see 94C11}
- 94D99** None of the above, but in this section

## **97-XX Mathematics education**

- 97-00** General reference works (handbooks, dictionaries, bibliographies, etc.) pertaining to mathematics education
- 97-01** Introductory exposition (textbooks, tutorial papers, etc.) pertaining to mathematics education
- 97-02** Research exposition (monographs, survey articles) pertaining to mathematics education
- 97-03** History of mathematics education [Consider also classification numbers pertaining to Section 01]
- 97-06** Proceedings, conferences, collections, etc. pertaining to mathematics education
- 97-11** Research data for problems pertaining to mathematics education

## **97Axx History and society (aspects of mathematics education)**

- 97A30** History in mathematics education {For mathematics history, see 01-XX; for biographies, see 01A70; for history of mathematics education, see 97-03}
- 97A40** Mathematics education and society {For sociology (and profession) of mathematics, see 01A80}
- 97A99** None of the above, but in this section

## **97Bxx Educational policy and systems**

- 97B10** Mathematics educational research and planning
- 97B20** Educational policy for general education
- 97B30** Educational policy for vocational education
- 97B40** Educational policy for higher education
- 97B50** Mathematics teacher education
- 97B60** Educational policy for adult and further education
- 97B70** Syllabuses, educational standards
- 97B99** None of the above, but in this section

## **97Cxx Psychology of mathematics education, research in mathematics education**

- 97C10** Comprehensive works on psychology of mathematics education
- 97C20** Affective behavior and mathematics education
- 97C30** Cognitive processes, learning theories (aspects of mathematics education)
- 97C40** Intelligence and aptitudes (aspects of mathematics education)
- 97C50** Language and verbal communities (aspects of mathematics education)
- 97C60** Sociological aspects of learning (aspects of mathematics education)
- 97C70** Teaching-learning processes in mathematics education
- 97C99** None of the above, but in this section

## **97Dxx Education and instruction in mathematics**

- 97D10** Comprehensive works and comparative studies on education and instruction in mathematics
- 97D20** Philosophical and theoretical contributions (maths didactics)
- 97D30** Objectives and goals of mathematics teaching
- 97D40** Mathematics teaching methods and classroom techniques
- 97D50** Teaching mathematical problem solving and heuristic strategies
- 97D60** Student assessment, achievement control and rating (aspects of mathematics education)
- 97D70** Learning difficulties and student errors (aspects of mathematics education)
- 97D80** Mathematics teaching units and draft lessons
- 97D99** None of the above, but in this section

## **97Exx Education of foundations of mathematics**

- 97E10** Comprehensive works on education of foundations of mathematics
- 97E20** Philosophy and mathematics (educational aspects)
- 97E30** Logic (educational aspects)
- 97E40** Language of mathematics (educational aspects)
- 97E50** Reasoning and proving in the mathematics classroom
- 97E60** Sets, relations, set theory (educational aspects)
- 97E99** None of the above, but in this section

## **97Fxx Education of arithmetic and number theory**

- 97F10** Comprehensive works on education of arithmetic and number theory
- 97F20** Pre-numerical stage, concept of numbers
- 97F30** Natural numbers (educational aspects)
- 97F40** Integers, rational numbers (educational aspects)
- 97F50** Real numbers, complex numbers (educational aspects)
- 97F60** Number theory (educational aspects)
- 97F70** Measures and units (educational aspects)
- 97F80** Ratio and proportion, percentages (educational aspects)
- 97F90** Real life mathematics, practical arithmetic (educational aspects)
- 97F99** None of the above, but in this section

## **97Gxx Geometry education**

- 97G10** Comprehensive works on geometry education
- 97G20** Informal geometry (educational aspects)
- 97G30** Area and volume (educational aspects)
- 97G40** Plane and solid geometry (educational aspects)
- 97G50** Transformation geometry (educational aspects)
- 97G60** Plane and spherical trigonometry (educational aspects)
- 97G70** Analytic geometry, vector algebra (educational aspects)
- 97G80** Descriptive geometry (educational aspects)
- 97G99** None of the above, but in this section

## **97Hxx Algebra education**

- 97H10** Comprehensive works on algebra education
- 97H20** Elementary algebra (educational aspects)
- 97H30** Equations and inequalities (educational aspects)
- 97H40** Groups, rings, fields (educational aspects)
- 97H50** Ordered algebraic structures (educational aspects)
- 97H60** Linear algebra (educational aspects)
- 97H99** None of the above, but in this section

## **97Ixx Analysis education**

- 97I10** Comprehensive works on analysis education
- 97I20** Mappings and functions (educational aspects)
- 97I30** Sequences and series (educational aspects)
- 97I40** Differential calculus (educational aspects)
- 97I50** Integral calculus (educational aspects)
- 97I60** Functions of several variables (educational aspects)
- 97I70** Functional equations (educational aspects)
- 97I80** Complex analysis (educational aspects)
- 97I99** None of the above, but in this section

## **97Kxx Education of combinatorics, graph theory, probability theory, and statistics**

- 97K10** Comprehensive works on combinatorics, graph theory, and probability (educational aspects)
- 97K20** Combinatorics (educational aspects)
- 97K30** Graph theory (educational aspects)
- 97K40** Descriptive statistics (educational aspects)
- 97K50** Probability theory (educational aspects)
- 97K60** Distributions and stochastic processes (educational aspects)
- 97K70** Foundations and methodology of statistics (educational aspects)
- 97K80** Applied statistics (educational aspects)
- 97K99** None of the above, but in this section

## **97Mxx Education of mathematical modeling and applications of mathematics**

- 97M10** Modeling and interdisciplinarity (aspects of mathematics education)
- 97M20** Mathematics in vocational training and career education
- 97M30** Financial and insurance mathematics (aspects of mathematics education)
- 97M40** Operations research, economics (aspects of mathematics education)
- 97M50** Physics, astronomy, technology, engineering (aspects of mathematics education)
- 97M60** Biology, chemistry, medicine (aspects of mathematics education)
- 97M70** Behavioral and social sciences (aspects of mathematics education)
- 97M80** Arts, music, language, architecture (aspects of mathematics education)
- 97M99** None of the above, but in this section



## **97Nxx Education of numerical mathematics**

- 97N10** Comprehensive works education of numerical mathematics
- 97N20** Rounding, estimation, theory of errors (educational aspects)
- 97N30** Numerical algebra (educational aspects)
- 97N40** Numerical analysis (educational aspects)
- 97N50** Interpolation and approximation (educational aspects)
- 97N60** Mathematical programming (educational aspects)
- 97N70** Discrete mathematics (educational aspects)
- 97N80** Mathematical software, computer programs (educational aspects)
- 97N99** None of the above, but in this section

## **97Pxx Computer science (educational aspects)**

- 97P10** Comprehensive works on computer science (educational aspects)
- 97P20** Theoretical computer science (educational aspects)
- 97P30** Systems, databases (educational aspects)
- 97P40** Programming languages (educational aspects)
- 97P50** Programming techniques (educational aspects)

**97P80** Artificial intelligence (educational aspects)

**97P99** None of the above, but in this section

## **97Uxx Educational material and media and educational technology in mathematics education**

**97U10** Comprehensive works on educational material and media and educational technology in mathematics education

**97U20** Textbooks, textbook research (aspects of mathematics education)

**97U30** Teachers' manuals and planning aids (aspects of mathematics education)

**97U40** Problem books, competitions, examinations (aspects of mathematics education)

**97U50** Computer-assisted instruction, e-learning (aspects of mathematics education)

**97U60** Manipulative materials (aspects of mathematics education)

**97U70** Technological tools, calculators (aspects of mathematics education)

**97U80** Audiovisual media (aspects of mathematics education)

**97U99** None of the above, but in this section