

# MSC2020-Mathematics Subject Classification System

Associate 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 Zentralblatt für Mathematik (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 Chief Editor of zbMATH in July 2016. This document results from the MSC revision process that has been going on since then. MSC2020 will be fully deployed from January 2020.

The editors of MR and zbMATH deploying this revision therefore ask for feedback on remaining errors to help in this work, which should be given through e-mail to [feedback@msc2020.org](mailto:feedback@msc2020.org). They are grateful for the many suggestions that were received previously, which have greatly influenced what we have.

## 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 Lukasiewicz 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 [14F08](#), [14H60](#), [14J60](#), [18F20](#), [32Lxx](#), [46M20](#)]
- 14F08** 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 semi-group 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 Hopf 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 (associative rings and algebras)

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)

16U90 Generalized inverses (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 (general theory) [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, triple or triad), algebras for monads, homology and derived functors for monads [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](#), [14F08](#), [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 [14F08](#), [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 [14F08](#), [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 (Frattni, 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 for Riemann surfaces [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 (pseudo-analytic,  $p$ -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
- 33Exx 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

### **33Fxx 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

### **34Axx 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 [65Lxx](#)}

**34A55** Inverse problems involving ordinary differential equations

**34A60** Ordinary differential inclusions [See also [49J21](#), [49K21](#)]

**34A99** None of the above, but in this section

### **34Bxx Boundary value problems for ordinary differential equations {For ordinary differential operators, see 34Lxx}**

**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 [See also [37C79](#)]
- 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 [37C79](#)]
- 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** Parametrics 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](#)}
- 35Q49** Transport equations {For calculus of variations and optimal control, see [49Q22](#); for fluid mechanics, see [76F25](#); for statistical mechanics, see [82C70](#), [82D75](#); for operations research, see [90B06](#); for mathematical programming, see [90C08](#)}
- 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
- 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
- 37A44** 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
- 37B51** 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
- 37C79** Symmetries and invariants of dynamical systems [See also [34C14](#), [34K04](#)]
- 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
- 37F31** 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
- 37F44** 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](#)]
- 37J06** General theory of finite-dimensional Hamiltonian and Lagrangian systems, Hamiltonian and Lagrangian structures, symmetries, invariants
- 37J11** 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
- 37J46** Periodic, homoclinic and heteroclinic orbits of finite-dimensional Hamiltonian systems
- 37J51** 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](#)]
- 37K06** 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](#)]
- 37K65** Hamiltonian systems on groups of diffeomorphisms and on manifolds of mappings and metrics
- 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](#), [37A44](#)]
- 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
- 39A36** 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); completion (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, quasidiagonal and nonquasidiagonal 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** General theory of 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** General theory of 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]

- 49L12 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]

49M41 PDE constrained optimization (numerical aspects)

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

**49Q22** 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  $-$ -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
- 53A31** 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 (Hermite-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 Spin<sup>c</sup> 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** Extremally 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](#)]
- 60J74** 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](#), [60J74](#), [60J76](#)] {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 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 and related topics**

**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** General theory of 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

**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
- 74G22** 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

**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

**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**

**76N06** 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**
- 76T06** 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** General theory of 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

**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](#)]
- 80A19** Diffusive and convective heat and mass transfer, heat flow
- 80A21** Radiative heat transfer
- 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](#)]
- 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
- 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

**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** Introductory 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
- 93C43** 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
- 93D23** 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