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</table>
500  **Natural sciences and mathematics**

Natural sciences: sciences that deal with matter and energy, or with objects and processes observable in nature

Class here interdisciplinary works on natural and applied sciences

Class scientific principles of a discipline or subject with the discipline or subject, using notation 015 from Table 1, e.g., scientific principles of photography 770.15

Natural history is classed in 508

*For applied sciences, see 600*

*See Manual at 500 vs. 001; 500 vs. 338.926, 351.855; 500 vs. 600*

.2  **Physical sciences**

*For astronomy and allied sciences, see 520; physics, 530; chemistry and allied sciences, 540; earth sciences worlds, 550*

*See Manual at 530 vs. 500.2*

.5  **Space sciences**

Class astronomy in 520; earth sciences in other worlds in 550; space sciences aspects of other subjects with the subject, e.g., chemical reactions in space in 541.390919

.8  **History and description with respect to kinds of persons [formerly 509]**

Add to base number 500.8 the numbers following 08 in —081—089 from Table 1, e.g., women as scientists 500.82

501  **Philosophy and theory**

Class scientific method as a general research technique in 001.42, scientific method applied in the natural sciences in 507.2

502  **Miscellany**

.8  **Auxiliary techniques and procedures; apparatus, equipment, materials**

.82  **Microscopy**

Class here interdisciplinary works on microscopy

Class manufacture of microscopes in 681.413

.822  **Simple microscopes**

.823  **Compound microscopes**
.824 Ultramicroscopes
.825 Electron microscopes

503 **Dictionaries, encyclopedias, concordances**

[504] [Unassigned]
Most recently used in Edition 16

505 **Serial publications**

506 **Organizations and management**

507 **Education, research, related topics**

.2 **Research**

*See also 001.4 for research covering science in general*

*See Manual at 500 vs. 001*

.8 **Use of apparatus and equipment in study and teaching**

Class here science fair projects, science projects in schools

508 **Natural history**

Class here description and surveys of phenomena in nature

Do not use for history and description of natural sciences and mathematics with respect to groups of persons; class in 500.8

Class natural history of organisms in 574

*See Manual at 508 vs. 574, 910, 304.2*

.09 **Historical and persons treatment**

Class geographical treatment in 508.3–508.9

.3 **Treatment by areas, regions, places in general; by specific continents, countries, localities in the ancient world**

Add to base number 508.3 notation 1 or 3 from Table 2, e.g., natural history of the sea 508.3162, of ancient Greece 508.338

.4–.9 **Treatment by specific continents, countries, localities in the modern world**

Add to base number 508 notation 4–9 from Table 2, e.g., natural history of Brazil 508.81

509 **Historical, geographical, persons treatment**

History and description with respect to kinds of persons relocated to 500.8

Class historical, geographical, persons treatment of natural phenomena in 508
510 Mathematics

Class here finite mathematics

*See Manual at 003, T1—011 vs. 510, T1—0151; 005.1 vs. 510; 510, T1—0151 vs. 004—006, T1—0285*

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.1 Philosophy and theory

Including metamathematics

Class mathematical logic in 511.3

511 General principles

Class topics found here applied to a specific branch of mathematics with the branch, e.g., arithmetic approximation 513.24

.2 Mathematical systems

.22 Inductive and intuitive mathematics

.24 Deductive mathematics

.3 Mathematical (Symbolic) logic

Including automata theory *formerly also* 001.535, infinite-state machines *formerly also* 621.3819594, Turing machines *formerly also* 621.381952, 621.381954, sequential machines *formerly also* 629.891, formal languages, machine theory; completeness theorem, continuum hypothesis, decidability, Godel’s theorem

Class here logic operators; axioms, postulates, proof, hypotheses; predicate calculus, propositional calculus

Class proof for inductive and intuitive mathematics in 511.22

.32 Sets

*For point sets, see 511.33*

.322 Set theory

Class here transfinite numbers *formerly 512.7*

.324 Algebra of sets (Boolean algebra)

.33 Relations, lattices, ordered systems and structures

Examples: equations, functions, mappings, point sets, transformations
.35 Recursion theory
   Including recursive functions

.4 Approximations and expansions
   Methods
   Examples: curve fitting, interpolation, splines

.43 Error analysis

.5 Theory and construction of graphs
   Including nomography, trees

.6 Combinatorial analysis
   Including combinatorial configurations and designs
   Class graph theory in 511.5

.62 Enumeration

.64 Permutations and combinations

.65 Choice
   See also 519.3 for decision making in game theory

.66 Maxima and minima

.8 Mathematical models (Mathematical simulation)
   Including algorithms

512 Algebra and number theory
   Including numerical algebra

Class here universal algebra, modern algebra (abstract algebra combined with number theory)

Use 512.001–512.009 for standard subdivisions

Foundations of algebra is classed in 512.9

SUMMARY

512.02 Abstract algebra
   .1 Algebra combined with other branches of mathematics
   .2 Groups and group theory
   .3 Fields
   .4 Rings, integral domains, ideals
   .5 Linear, multilinear, multidimensional algebras
   .7 Number theory
   .9 Foundations of algebra

.02 Abstract algebra
   For subdivisions of abstract algebra, see 512.2–512.5
.1 Algebra combined with other branches of mathematics
   
   For arithmetic and algebra, see 513.12

   See Manual at 510: Combination of topics

.12 Algebra and Euclidean geometry

.13 Algebra and trigonometry

.14 Algebra and analytic geometry

.15 Algebra and calculus

> 512.2–512.5 Subdivisions of abstract algebra

   Class comprehensive works in 512.02

.2 Groups and group theory

   Class here cosets, semigroups, subgroups; partitions; cyclic, permutation,
   Abelian (commutative) groups; Brauer groups

   For topological and related algebras and groups, see 512.55; algebraic
   topology, 514.2

.[.22] Group theory

   Number discontinued; class in 512.2

.24 Algebras based on group properties

   Examples: Jordan algebra [formerly 512.53], commutative, associative,
   nonassociative, flexible, free algebras

   Class algebras defined by dimension in 512.53, topological algebras in
   512.55

.3 Fields

   Class here field theory, Galois theory

   Class linear algebra in 512.5, number theory in 512.7

.[.32] Field theory

   Number discontinued; class in 512.3

.[.33] Abstract algebraic geometry

   Relocated to 516.35

.4 Rings, integral domains, ideals

   Including subrings, extension theory

   Class here modules [formerly 512.522], radical theory [formerly 512.94]

   For fields, see 512.3
.5  Linear, multilinear, multidimensional algebras
    Including Cayley algebra, quaternions
    Class here vector algebra, linear algebra combined with analytic geometry
    Standard subdivisions are added for combined linear, multilinear, multidimensional algebras, for linear algebra alone
    Geometry of numbers relocated to 512.75
    Class foundations of algebra in 512.9, analysis combined with linear algebra in 515.14

    See Manual at 510: Combination of topics

.52  Vector spaces
    Class bilinear forms in 512.944, topological vector spaces in 515.73

[.522]  Modules
    Relocated to 512.4

[.523]  Vector spaces
    Number discontinued; class in 512.52

.53  Algebras defined by dimension of space and other geometric algebras
    Jordan algebra relocated to 512.24

.55  Topological and related algebras and groups
    Examples: homological algebra, categories, morphisms, functors; toposes; Banach, Frechet, Hopf, Lie, operator (e.g., C*, Von Neumann, W*), reductive, Stein, uniform algebras and their groups
    Including algebraic K-theory

    For differential and difference algebras, see 512.56; factor algebras, 512.57

.56  Differential and difference algebras

.57  Factor algebras
    Examples: Clifford, exterior, spinor, tensor algebras

.7  Number theory
    Class here lattices
    Transfinite numbers relocated to 511.322

    For the theory of equations, see 512.94

.72  Elementary number theory
    Including combinations, congruence, continued fractions, Diophantine equations, divisibility, Fibonacci numbers, natural numbers, operations, power residues, prime numbers, quadratic residues, representations, residues, roots, sequences of integers, sieves, transformations
    Geometry of rational numbers relocated to 512.75
.73 Analytic number theory
   Including additive properties, Diophantine approximations, distribution
to theory of prime numbers, functions, modular forms, multiplicative
properties, number theoretic functions, partitions, Riemannian hypothesis,
transcendental numbers

.74 Algebraic number theory
   Including algebraic function theory, class groups, class numbers,
   discriminants, factorization, field extension, fields, ideals, p-adic numbers,
   quadratic forms, reciprocity, rings, unit theory

.75 Geometry of numbers [formerly 512.5]
   Class here the geometry of rational numbers [formerly 512.72]

.76 Probabilistic number theory

.9 Foundations of algebra
   Class algebra combined with other branches of mathematics in 512.1
   .900 1-.900 9 Standard subdivisions
   [.904] Elementary, intermediate, advanced algebras
      Numbers discontinued; class in 512.9
   .92 Algebraic operations
      Class here addition, subtraction, multiplication, division
   .922 Exponents and logarithms
   .923 Root extraction
      Including factoring
   .924 Approximation, ratio, proportion
   .925 Combinations, permutations, distributions
   .93 Simple algebraic and geometric progressions
   .94 Theory of equations
      Radical theory relocated to 512.4
   .942 Specific types and systems of equations
      Examples: binomial, polynomial, quadratic, cubic, quartic, mixed
   .943 Determinants and matrices
   .943 2 Determinants
      Class determinants of matrices in 512.9434
   .943 4 Matrices
      Including eigenvalues and eigenvectors
   .944 Theory of forms and algebraic invariant theory
Algebra of non-equation functions

Example: rational functions

*For inequalities, see 512.97*

*See also 512.944 for quantics*

.97

Inequalities

513 Arithmetic

Including numeracy

.1 Arithmetic combined with other branches of mathematics

*See Manual at 510: Combination of topics*

.12 Arithmetic and algebra

.122 Separate treatment

.123 Combined treatment

.13 Arithmetic and geometry

.132 Separate treatment

.133 Combined treatment

.14 Arithmetic, algebra, geometry

.142 Separate treatment

.143 Combined treatment

.2 Arithmetic operations

Decimal (base 10) system relocated to 513.55

.21 Basic operations

.211 Addition

  Including counting

.212 Subtraction

.213 Multiplication

.214 Division

.22 Exponents and logarithms

.23 Root extraction

  Examples: factoring; square root, cube root

.24 Approximation, ratio, proportion

  Including percentage

.25 Combinations, permutations, distributions

.26 Fractions
.4 Arithmetic and geometric progressions

.5 Numeration systems
   - Examples: base 3, 5, 20 systems
   - Binary (Base 2) system
   - Octal (Base 8) system
   - Decimal (Base 10) system [formerly 513.2]
   - Duodecimal (Base 12) system
   - Sexadecimal (Hexadecimal, Base 16) system

.6 Nonweighted systems
   - Example: modular arithmetic

.9 Rapid calculations, shortcuts, ready reckoners
   - Former heading: Special purpose arithmetics
   - This number should not be confused with the idea of arithmetic formulas
     513.0212. Class here hints on the methods of solving arithmetic problems
     rapidly, e.g., when adding nines add an equal number of tens and then subtract
     one for each nine added; mental arithmetic

[.92] Rapid calculations and shortcuts
   - Number discontinued; class in 513.9

[.93] Business arithmetic
   - Relocated to 650.01513

514 Topology
   - Class here analysis situs, homogeneous spaces, homeomorphisms, mappings
   - Class topology combined with analysis in 515.13 
     *For topological vector spaces, see 515.73*

.2 Algebraic topology
   - *See also 512.55 for topological algebras*

.22 Combinatorial topology

.223 Combinatorial elements
   - Examples: simplexes, complexes, nets, topological manifolds

.224 Structures and spaces
   - Examples: sheaves, fiber bundles (fiber spaces), knots, links, braids, path
     spaces

.23 Homology and cohomology theories
   - Including K-theory
     *See also 512.55 for topological groups*
514 Mathematics

.24 Homotopy theory
   Including retracts

.3 Topology of spaces
   Class here manifold topology, metric topology

.32 Systems and spaces
   Use 514.32001–514.32009 for standard subdivisions

.320 Uniform spaces

.320.2 Uniform spaces

.320.3 Derived spaces

.322 Point set topology (General topology)

.323 Proximity topology

.7 Analytic topology

.72 Differential topology
   Including foliations

.74 Global analysis

See also 515 for global analysis in analysis

515 Analysis

Including comprehensive works on global analysis

Class here calculus, comprehensive works on the theory of functions

Class probabilities in 519.2, the theory of a specific function or group of functions
   with the subject, e.g., analysis of continued fractions 512.72

SUMMARY

515.1 Analysis and calculus combined with other branches of mathematics

.2 General aspects

.3 Differential calculus and equations

.4 Integral calculus and equations

.5 Special functions

.6 Other analytic methods

.7 Functional analysis

.8 Functions of real variables

.9 Functions of complex variables

.1 Analysis and calculus combined with other branches of mathematics

For algebra and calculus, see 512.15

See Manual at 510: Combination of topics

.13 Analysis and topology

.14 Analysis and linear algebra

.15 Calculus and analytic geometry

.16 Calculus and trigonometry

727
.2 General aspects

Class a specific application with the subject, e.g., the expansion of functions of real variables 515.8234

.22 Properties of functions

.222 Continuity, dimension, limit

.223 Uniformity and multiformity

Including Riemann surfaces, analytic spaces (generalization of Riemann surfaces to n-dimensional spaces)

Class here uniform and multiform functions

.23 Operations on functions

For differentiation, see 515.33; integration, 515.43

.232 Determination of functions

.234 Expansion of functions

.235 Evaluation of functions

Real-, complex-, vector-valued functions relocated to 515.7

.24 Sequences and series

Class here infinite processes

.243 Series

Including summability

Class here infinite series

Class number theory of continued fractions in 512.72

.243.2 Power series

.243.3 Fourier and harmonic analysis

Class abstract harmonic analysis in 515.785, Fourier transforms in 515.723

.25 Equations and functions

.252 By degree

Examples: linear, nonlinear, quadratic equations

.253 By property

Examples: homogeneous, indeterminate, reciprocal equations

.254 By origin

Example: conditional equations

.26 Inequalities
.3  **Differential calculus and equations**

Class differential topology in 514.72, differential operators in 515.7242, differential geometry in 516.36

.33  **Differential calculus**

Including ordinary, partial, total differentiations; total and directional derivatives, mean value theorems, differentials

Class numerical differentiation in 515.623, vector differentiation in 515.63, probability differentiation in 519.2

.35  **Differential equations**

Class here the Cauchy problem; orders, degrees; comprehensive works on boundary-value problems; bifurcation, perturbation, stability theories

Class boundary-value problems of finite differences in 515.62

.352  **Ordinary differential equations**

Class here dynamical systems

.353  **Partial differential equations**

Examples: elliptic, hyperbolic, parabolic equations

.354  **Linear differential equations**

Class linear ordinary differential equations in 515.352, linear partial differential equations in 515.353

.355  **Nonlinear differential equations**

Class nonlinear ordinary differential equations in 515.352, nonlinear partial differential equations in 515.353

.36  **Differential inequalities**

.37  **Differential forms**

.38  **Mixed equations**

Examples: integro-differential, difference-differential equations

.4  **Integral calculus and equations**

Class special functions in 515.5, integral transforms in 515.723, integral geometry in 516.362

.42  **Theory of measure and integration**

Including ergodic theory

*For functionals, see 515.74*
Integral calculus

Including integration, summation, arc length, cubature, quadrature; Cauchy, definite, Denjoy, Green, Haar, improper, Lebesgue, line, Poisson, Poisson-Stieltjes, proper, Riemann, Stokes', surface integrals

Class vector integration in 515.63, numerical integration in 515.624, probability integration in 519.2

Integral equations

Integral inequalities

Special functions

Eulerian integrals

Examples: gamma, beta functions

Harmonic functions

Examples: Bessel, Hankel, Laplace, Legendre, Neumann functions

Mathieu functions

Orthogonal polynomials

Examples: Chebyshev, Hermite, hypergeometric, Jacobi, Lagrange, Laguerre, Legendre polynomials

Zeta function

Class the application of the Riemann zeta function with respect to prime number theory in 512.73

Other analytic methods

For functional analysis, see 515.7

Calculus of finite differences

Class here boundary-value problems when either limit has a numerical value

Numerical differentiation

Numerical integration

Difference equations

Class difference-differential equations in 515.38

Vector, tensor, spinor analysis

Including vector and tensor calculus

Class algebraic vector analysis in 512.52, geometric vector analysis in 516.182

Calculus of variations

Including control theory

See also 629.8312 for control theory
.7 Functional analysis

Class here comprehensive works on real-, complex-, vector-valued functions [all formerly 515.235]; abstract potential theory

Class the theory of measure and integration in 515.42, potential theory in 515.9

For topological algebras, see 512.55; functions of real variables, 515.8; functions of complex variables, 515.9

.72 Operational calculus

Class a specific application with the subject, e.g., differential operators in topological vector spaces 515.73

.722 Spectral and representation theories

.722 2 Spectral theory

.722 3 Representation theory

Including forms

Generalized functions relocated to 515.782

Class abstract harmonic analysis in 515.785

.723 Transforms (Integral operators)

Examples: Fourier, Hilbert, Laplace, Legendre, Z transforms

.724 Operator theory

For integral operators, see 515.723

.724 2 Differential operators

Example: elliptic operators

.724 6 Linear operators

Class linear integral operators in 515.723, linear differential operators in 515.7242

.724 8 Nonlinear operators

Class nonlinear integral operators in 515.723, nonlinear differential operators in 515.7242

.73 Topological vector spaces

Examples: spaces of continuous functions; spaces of measurable functions, e.g., $L^p$ spaces, Orlicz spaces; spaces of analytic functions; Hermitian (unitary) and Riesz spaces

Including mappings between spaces

Class here linear topological spaces

For functionals, see 515.74

.732 Banach spaces

Class here normed linear spaces

For Hilbert spaces, see 515.733
515 Dewey Decimal Classification

.733 Hilbert spaces
   Class here inner product spaces

.74 Functionals

.78 Special topics

.782 Distribution theory
   Including duality, distribution spaces, Sobolev spaces
   Class here generalized functions [formerly 515.7223]

.783 Abstract measure theory

.784 Valuation theory

.785 Abstract harmonic analysis
   Including Fourier analysis on groups

.8 Functions of real variables
   Class the combined treatment of the functions of real and complex variables in 515.9

.82 General aspects
   Add to base number 515.82 the numbers following 515.2 in 515.22–515.26, e.g., the expansion of functions 515.8234
   Class a specific application with the subject, e.g., the expansion of functions of several real variables 515.84

.83 Functions of one real variable

.84 Functions of several real variables

.88 Specific types of real variable functions
   Example: real variable analytic functions

.9 Functions of complex variables
   Class here the classical theory of functions, conformal mapping, automorphic functions, potential theory

.92 General aspects
   Add to base number 515.92 the numbers following 515.2 in 515.22–515.26, e.g., expansion of functions 515.9234
   Class a specific application with the subject, e.g., expansion of functions of several complex variables 515.94

.93 Functions of one complex variable

.94 Functions of several complex variables

.98 Specific types of complex variable functions
   Examples: entire, pseudonanalytic functions
.982 Meromorphic functions
.983 Elliptic functions
   Class special elliptic functions in 515.5
.984 Theta function

516 Geometry

Use 516.001–516.009 for standard subdivisions

Class here geometry combined with topology

Class algebra combined with geometry in 512.1, arithmetic combined with geometry in 513.13, analysis combined with geometry in 515.1, geometric probability in 519.2

For topology, see 514

SUMMARY

516.02–.08 [Classical and modern geometry; planes, solids, manifolds, convex sets]
   .1 General aspects
   .2 Euclidean geometry
   .3 Analytic geometries
   .4 Affine geometry
   .5 Projective geometry
   .6 Abstract descriptive geometry
   .9 Non-Euclidean geometries

.02 Classical geometry
.04 Modern geometry
.05 Planes
.06 Solids
.07 Manifolds
.08 Convex sets

.1 General aspects

Class here metric geometry, transformations, automorphisms

Class general aspects applied to a specific geometry with the geometry, e.g., angles in Euclidean geometry, 516.215

.12 Incidence geometry
.13 Combinatorial and constructive geometry
.15 Geometric configurations, measures, shapes

Examples: angles, circles, conic sections, cubes, curves, polyhedrons, spheres, spirals, squares, surfaces; pattern, shapes, sizes, space

Class a specific configuration, measure, shape with the subject, e.g., measuring the sphere in solid geometry 516.23

Including mensuration
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<td>Class here congruences, similarity, metric geometry</td>
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<td>Class a specific type of Euclidean geometry with the subject, e.g., Euclidean analytic geometry 516.3</td>
</tr>
<tr>
<td>.204</td>
<td>Famous problems</td>
</tr>
<tr>
<td></td>
<td>Contains trisecting an angle, squaring the circle, doubling the cube</td>
</tr>
<tr>
<td>.21</td>
<td>General aspects</td>
</tr>
<tr>
<td></td>
<td>Add to base number 516.21 the numbers following 516.1 in 516.12–516.18, e.g., angles 516.215</td>
</tr>
<tr>
<td></td>
<td>Class a specific application with the subject, e.g., angles in plane geometry 516.22</td>
</tr>
<tr>
<td>.22</td>
<td>Plane geometry</td>
</tr>
<tr>
<td></td>
<td>Including the Pythagorean theorem</td>
</tr>
<tr>
<td>.23</td>
<td>Solid geometry</td>
</tr>
<tr>
<td>.24</td>
<td>Trigonometry</td>
</tr>
<tr>
<td>.242</td>
<td>Plane trigonometry</td>
</tr>
<tr>
<td>.244</td>
<td>Spherical trigonometry</td>
</tr>
<tr>
<td>.3</td>
<td><strong>Analytic geometries</strong></td>
</tr>
<tr>
<td></td>
<td>Class linear algebra combined with analytic geometry in 512.5, analytic affine geometry in 516.4, analytic projective geometry in 516.5</td>
</tr>
<tr>
<td>.32</td>
<td>Plane analytic geometry</td>
</tr>
<tr>
<td>.33</td>
<td>Solid analytic geometry</td>
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<tr>
<td>.34</td>
<td>Analytic trigonometry</td>
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<tr>
<td></td>
<td>Plane and spherical</td>
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<tr>
<td>Code</td>
<td>Topic</td>
</tr>
<tr>
<td>------</td>
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</tr>
</tbody>
</table>
| .35  | Algebraic geometry  
*Geometries based on linear algebra*
*Examples: enumerative geometry, lattice point geometry*
Class here abstract algebraic geometry [*formerly 512.33*], birational and conformal transformations, intersections, connections, dual geometries; bilinear and sesquilinear forms; polytopes; complex multiplication |
| .352 | Curves and surfaces on projective and affine planes  
*Class here the theory of curves* |
| .353 | Algebraic varieties of higher dimensions |
| .36  | Differential and integral geometry  
*Class here surfaces, curves, differentiable manifolds*
*Use 516.36001–516.36009 for standard subdivisions*
*For metric differential geometries, see 516.37* |
| [.360 2] | Classical differential geometry  
*Relocated to 516.363* |
| [.360 4] | Modern differential geometry  
*Relocated to 516.362* |
| .362 | Integral geometry (Global differential geometry)  
*Including arc length, curvature, evolutes, fiber spaces (fiber bundles), geodesics, involutes, tangent space at a point; analytic, convex, developable, minimal, ruled surfaces; analytic, asymptotic, minimal curves*
*Class here modern differential geometry [*formerly 516.3604*]* |
| .363 | Local and intrinsic differential geometry  
*Curvature and torsion*
*Class here classical differential geometry [*formerly 516.3602*]* |
| .37  | Metric differential geometries |
| .372 | Euclidean geometry |
| .373 | Riemannian geometry [*formerly also 516.92*]  
*Example: Sasakian*
*Einstein geometry relocated to 516.374* |
| .374 | Minkowski geometry [*formerly 516.93*]  
*Example: Einstein geometry [*formerly 516.373*]* |
| .375 | Finsler geometry |
| .376 | Cartan geometry |
The 20th edition of the Dewey Decimal Classification was designed by Lisa Hanifan of Albany, New York. Edition 20 is the first edition to be generated from an online database. Database design, technical support, and programming for this edition were provided by John J. Finni and Cora M. Arsenault from Inforonics, Inc., of Littleton, Massachusetts. Composition was done in Times Roman and Helvetica on a Linotronic L100 under the supervision of Inforonics, Inc. The book was printed and bound by Hamilton Printing Company of Rensselaer, New York.