Index

@, 238
$\mathcal{G}_{\mathcal{A},t}$, 260
$T(\mathcal{A})$, 252
$T(\varphi)$, 270
$\mathcal{T}^{\omega}_{A,k}$, 251
$\mathcal{T}^{\mathrm{unr}}_{\Sigma}$, 237
AC^0, 449
ACC^0, 449
CC^0, 449
$\mathcal{D}$-class, 932
  rank, 932
  regular, 932
  structure group, 932
NC, 449
NC^1, 449
TC^0, 449
$dom(u)$, 589
$cuts(u)$, 589
$inner\text{-}cuts(u)$, 589
ω-semigroup, 648
$\sim_s$, 591
*-semiring, 657
  left handed inductive, 677
  partial, 657
  right handed inductive, 677
  symmetric inductive, 678
$dom(t)$, 222
$\mathsf{ext}(t)$, 238
$\mathsf{fcns}(t)$, 238
k-automaton, 827
2-renewing sequence, 486

Ap, 512
abelianisation map, 871
abelian group
  free, 781, 792
abstract numeration system, 870
AC^0, 515
accepted, *see* automaton
accepting run
  of a tree automaton, 252
accessible, 6, 9
action
  free, 788
action algebra, 681
action lattice, 682
Adam, 257
adjacency matrix, 898
Alëshin group, 804, 808
  is free, 815
algebraic power series, 845
algebraic extension, 771
algorithm, *see* McNaughton–Yamada
almost finite type shift, 931
almost prime, 833
alphabet, 4
  canonical, 860
  involutive, 760
alphabetic
  matrix, 908
amalgamated free product, 782
amenable group, 807
analytic sets, 630
anticipation, block map, 898
aperiodic, *see* identities
aperiodic tiling, 89
aperiodic monoid, 771
Arden's lemma, 46, 49, 64, 66
arena, 257
arithmetic
  integer and real, 1083
  Presburger, 867, 1072
  progression, 859
arithmetical hierarchy, 716
array
  periodic, 885
  pseudo-periodic, 885
  ultimately periodic, 885
Artin-Schreier polynomial, 851
Artin group, 795
automata
  desert, 705

equivalent, 7
automata group, 761, 801–818
[regular] [weakly] branch, 809
contracting, 807
nuclear, 806
word problem, 806
automatic real numbers, 835
automatic sequence, 827
automatic set, 829
automatic group, 791–799
biautomatic, 794
normal forms, 791
quadratic isoperimetric inequality, 796
right/left, 794
word problem in quadratic time, 796
automatic structure, 792
geodesic, 793
with uniqueness, 793
automaton, 6, 43, 60, 663
α-extensible, 489
Černý, 484
accessible, 9
almost finite type, 334
behaviour of –, 43, 61, 65
bipartite, 921
bounded, 806
coaccessible, 9
complete, 9, 928
conjugate, 908
contained in another, 926
cyclic, 332
decomposition, 922
depth, 323
deterministic, 8, 913
dimension of –, 43
edge, 906
essential, 906
Eulerian, 490
expansion, 935
extended, 33
extension, 910
finite truncated, 783
Fischer, 916
flower, 763
in-split, 924
inherently weak, 1089
inverse, 762
involutive, 762
Kari, 492
Krieger, 914
labeled out-merge, 910
labeled out-split, 910
labeled in-merge, 908
labeled in-split, 908
language accepted by –, 43
language recognised by –, 43
left delay, 930
local, 26, 334, 926
looping tree
independent (ILTA), 695
minimal, 18, 320, 913, 917
minimal complete, 18
minimal nondeterministic, 345
Nerode, 17
one-cluster, 493
quotient, 320
real number, 882
real vector, 882
reduced, 913
reduction, 917
reversal, 322
right delay, 930
semi, 324
series accepted by –, 65
shift recognized, 906
simple, 337
slow, 324
slow for Hopcroft, 331
slow for Moore, 331
splitter, 321
Stallings, 764
standard, 10
standard –, 55
standard local, 928
standard weighted –, 67
state, 906
subset accepted by –, 61
symbolic conjugate, 919
synchronized, 913
synchronizing, 475
trie, 335
trim, 907

weak, 1083
weighted –, 64
automaton (of an expression)
derived term –, 69, 70
derived-term –, 59
equation –, 70
follow –, 70
Glushkov –, 54, 67, 70
position –, 54, 70
standard –, 55, 61, 67, 70
Thompson –, 57, 61
automorphism
orbits, 783
Whitehead, 774

backward, *see* closure
Baire space, 627
base complement, 1069, 1081
base-k expansion, 827
Basilica group, 805, 807
is amenable, 807
is regular weakly branch, 809
presentation, 808
basis, 449
complete, 449
numeration, 860
standard, 449
Baumslag-Solitar group, 800, 804
Beatty sequence, 91
behaviour, *see* automaton
Bertrand numeration basis, 861
beta-polynomial
canonical, 862
extended, 862
biautomatic group, 794
conjugacy problem, 797
bicombing, 799
bifix code, 768
bipartite automaton, 921
components, 922
bireversible Mealy automaton, 803, 814–818
bisimulation
strong timed, 1136
time-abstract, 1136
black-box checking, 378
Blikle net, 671
block, 898
substitution, 898
block decomposition, *see* matrix
block map, 883
anticipation, 898
memory, 898
sliding, 898
Boolean operators, 1068
Borel hierarchy, 627
Borel set, 627
boundary
hyperbolic, 772, 775
BOUNDED-SYNCHRONIZING-COLORING, 501
bounded gap, 863
bounded group, 806
is amenable, 807
is contracting, 807
Bowen-Franks group, 905
branched covering, 811
combinatorially equivalent, 811
branch group, 808–809
broken derivation, *see* derivation

canonical
beta-polynomial, 862
canonical alphabet, 860
Cantor normal form, 626
Cantor space, 627
cardinal arithmetic, 626
cardinal number, 624, 625
Cayley automaton, 813
Cayley graph, 781, 788
cellular automaton
one-way real-time, 701
Černý conjecture, 485
Černý function, 485
characteristic
polynomial, 861
sequence, 865
characteristic mapping, 355
characteristic vector, 491
Christol's theorem, 850
circuit, 447
class, 449

depth, 448
size, 448
uniformity, 448
width, 448
class of languages, 520
Classification Theorem, 904
clock constraint, 1131
k-bounded, 1132
diagonal, 1131
diagonal-free, 1131
closure
deterministic, 540
polynomial, 541
unambiguous, 540
closure (backward), 54
CNF, 626
co-induction, 71
coaccessible, 6, 9
coarser partition, 319
Cobham's theorem, 859, 1071, 1083
code
bifix, 768
sliding block, 883
coding, 828, 864
coefficient, *see* series
cofinality, 637
coincidence condition, 478
coloring (of a graph), 493
column division matrix, 902
combing of group, 794
commensurator of group, 771
common prefix, 340
commutator in groups, 760
complement, 1069
complete, 629
complete automaton, 928
complexity function, 865
components, 922
compressible pair, 496
compressible set, 496
computable operation, *see* language operation, computable
computable real number, 834
computation, 79
concatenation, 5, 453
mod$_p$-concatenation, 453
cone type, 790, 798
configuration in Hopcroft's algorithm, 326
confluent states, 335
congruence, 761, 917
syntactic, 918
Conjecture
Sakarovitch, 780
conjugacy
labeled, 908
of shifts, 899
conjugacy problem, 760
conjugate automata, 908
symbolic, 919
conjugates, 709
conjugate elements, 760
consistency problem, 363
constant term
of a language, 43
of a series, 64
of an expression, 43
constraint
equality, 1072, 1084
inequation, 1075, 1087
linear, 1072, 1075, 1076, 1084, 1087
modular, 1072, 1076
context
of a word, 917
context, right, 913, 914
context-free
word problem submonoid, 781
context-free language, 84
continuity, 629
continuous, 629
continuous operation, *see* language operation, continuous
contracting automaton/group, 806, 807, 812
contraction
graph, 905
symbol, 904
Conway, *see* semiring
Conway's leap, 658
couple, 481
Coxeter group, 795
Cramér's model, 832
Cross-Section Theorem, 83
Curtis–Lyndon–Hedlund Theorem, 898

cut, 589
    inner, 589
cyclic automaton, 332
cylinder, 883

D0L language, 100
decidable, 35
decision problem
    HD0L (ultimate) periodicity problem, 888
decomposition, 922
    prefix-suffix, 340
Decomposition Theorem, 903
delay
    left, 930
    right, 930
denoted, *see* expression
depth, *see* expression
depth of Moore's algorithm, 323
derivation (of an expression), 57, 61
    broken –, 70
    $\mathbb{K}$- –, 68
derivative (of an expression), 70
    partial –, 70
derived term (of an expression), 58, 68
    true –, 58, 68
derived-term, *see* automaton (of...)
deteministic transducer, 78
determinacy, 258, 630, 631
determined game, 631
deterministic automaton, 913
determinization
    NDD, 1075
digit, 1069
    sign, 1070, 1081
direct sum, 659
Dirichlet's theorem, 833
disjunctive rational subset, 780
distance
    geodesic, 768
    prefix metric, 772
    profinite, 516
    word metric, 790
divisible group, 852
division matrix, 902
document type definitions, 242
domain, 589
    of a tree, 251
dominating eigenvalue, 872
dot-depth, 462
DTD, 242
Dyck language, 781
dynamical system, 882
    factor, 882
    isomorphism, 883
    minimal, 882
    periodic, 882

edge, 898
    consecutive, 898
    initial vertex, 898
    source, 898
    target, 898
    terminal vertex, 898
edge in-merging map, 902
edge in-splitting map, 902
edge shift, 898
Ehrenfeucht-Fraïssé game, 533
Eilenberg's Theorem, 522
elementary equivalent matrices, 903, 911
emptiness problem, 1134
emptiness problem, 226
empty word, 76
encoding
    dual, 1081
    extension, 238
    first-child-next-sibling, 238
    fractional part, 1081, 1084
    integer numbers, 1069
    integer part, 1081, 1084
    integer vectors, 1070
    real numbers, 1081
    real vectors, 1081
    relation, 1068
    serialized, 1070, 1075, 1079, 1082
    valid, 1069, 1070, 1081
endomorphism
    extension, 775
    virtually injective, 775
entropy, 900
equation
    profinite, 518

explicit, 518
symmetrical, 520
equation automaton, *see* automaton (of...)
equations
with rational constraints, 783
equivalence
Moore, 322
Nerode, 320
equivalent, *see* expression
equivalent matrices
elementary, 911
strong shift, 911
symbolic elementary, 921
symbolic strong shift, 921
erasing substitution, 873
ergodic measure, 883
essential
automaton, 906
graph, 898
euclidean division, 626
Eva, 257
even shift, 897
existential theory of equations, 783
expansion
α-expansion, 861
automaton, 935
graph, 905
symbol, 904
explicit
profinite equation, 518
expression, 42
constant term of –, 43
depth of –, 42
derivation of –, *see* derivation
equivalent –s, 42
language denoted by –, 42
literal length of –, 42
rational –, 42
reduced –, 46, 66
regular, 453
regular –, 42
series denoted by –, 64
star height of –, 52
star-normal form, *see* star-normal form
valid –, 64
weighted rational –, 64, 71
extended
beta-polynomial, 862
extension
algebraic, 771
finite-index, 771
HNN, 782
extension automaton, 910

factor, 76
factor map, 883
FCNS, 238
fellow traveller property, 792
final state, 78
F_∞ group, 796
finite automata
non-uniform, 453
partially ordered, 470
two way, 470
finite automaton
alternating (AFA), 694
Boolean, 694
nondeterministic (NFA), 694
universal, 704
finite substitution, 77, 100
finite-state transduction, 79
finite-valued transduction, 80
finite order element, 760
first-order logic, 270
Fischer automaton, 916
fixed point, 673, 864
fixed point induction, 677, 678
fixed point of morphism, 828
fixpoint, 932
flow equivalent, 904
FO, 270
follow automaton, *see* automaton (of...)
forbidden factors, 897
forbidden pattern, 530
formula
first-order, 532
monadic second-order, 531
free
monoid, 5
semigroup, 5
variable, 867
free ω-semigroup, 648

free monoid, 57
free group, 761, 808, 816
  basis, 761
  free factor, 770
  generalized word problem, 765
  is residually finite, 773
  rank, 762
free product, 816
  amalgamated, 782
full shift, 897
function
  basis, 449
functorial star, 668
Fundamental theorem
  of finite automata, 42, 43, 61, 65
fundamental group, 788, 790
  of 3-fold is automatic, 795
  of negatively curved manifold, 799
fusion of states, 334
future of a state, 320

Gale-Stewart game, 631
game, 258
gate, 448
  generalized input, 448
  input, 448
  output, 448
genealogical order, 870
generalized power series, 851
generalized word problem, 761, 799
generating set, *see* monoid
generator, 629
geodesic distance, 768
Glushkov, *see* automaton (of...)
golden mean shift, 897
good substitution, 877
grammar
  Boolean, 699
  conjunctive, 698
    linear, 701
  context-free, 697
graph, 480, 898
  adjacency matrix, 898
  Cayley, 788
  contraction, 905
  edge, 898
  essential, 898
  Eulerian, 490
  expansion, 905
  higher edge, 899
  in-merge, 901
  in-split, 901
  morphism, 901
  of a letter, 496
  of constant out-degree, 493
  path, 898
  primitive, 494
  Schreier, 768, 779, 789, 807
  state, 898
  strongly connected, 490
  vertex, 898
  Wielandt, 500
graphs of groups, 782
greedy algorithm
  compression, 486
  extension, 489
Green relations, 932
Grigorchuk group, 800, 802, 804, 810
  conjugacy problem, 806
  generalized word problem, 806
  has intermediate growth, 810
  is regular branch, 809
  is torsion, 808
  presentation, 808
group, 451
  p-group, 451
  affine, 803, 813, 814
  Alëshin, 804
  amenable, 807
  Artin, 781, 795
  asynchronously automatic, 794
  automata, 761, 803
  automatic, 791
  of an automaton, 801
  ball of radius n in, 790
  Basilica, 805
  Baumslag-Solitar, 800, 804, 814
  biautomatic, 794
  bounded, 806
  braid, 795
  branch, 808, 809
  conjugacy separable, 806

Coxeter, 795
F_∞, 796
finite, 780
finitely presented, 761, 782, 788
free, 761
free abelian, 781, 792
free partially abelian, 781
functionally recursive, 803
graph, 781, 783
Grigorchuk, 804
growth, 809–811
Gupta-Sidki, 804
Heisenberg, 800
iterated monodromy, 812
Kazhdan, 818
lamplighter, 804
mapping class, 795
nilpotent, 774, 782, 800
p-, 774, 804, 808
relatively hyperbolic, 799
relators of a, 788
residually finite, 773
right angled Artin, 781
self-similar, 803, 811
semi-hyperbolic, 799
surface, 789
VH-, 817
virtually abelian, 782
virtually free, 781, 783
word-hyperbolic, 783, 797
growing
letter, 875
substitution, 876
growth
maximal, 876
growth type, 875, 876
less, 875
growth function, 790
growth of groups, 809–811
exponential, 810
intermediate, 810
non-uniformly exponential, 810
polynomial, 809
growth series, 790
gsm, 78
Gupta-Sidki group, 800, 802, 804
is regular branch, 809
is torsion, 808

Hahn's power series, 851
HD0L (ultimate) periodicity problem, 888
hedge, 238
hedge automaton
language of, 239
nondeterministic, 239
height, *see* star height, 222
height of a state, 336
Heisenberg group, 800
hierarchy
dot-depth, 462
higher
block shift, 899
edge graph, 899
HNN extension, 782
Hopcroft
automaton slow, 324
Hopcroft's algorithm
configuration, 326
splitter, 325
waiting set, 325
hyper-arithmetical set, 716
hyperbolic
boundary, 772, 798
space, 797
hyperbolic graph, 807
hyperbolic plane, 790

ideal, 657
idempotent, 932
identities
aperiodic –, 47, 70
natural –, 46, 66
rational –, 46
trivial –, 46, 66, 67
identity, 510
classical, 676
group, 667
matrix star, 660
permutation, 660
product star, 657
sum star, 657
identity of unary algebras, 479

heterotypical, 479
homotypical, 479
in-merge
graph morphism, 901
labeled, 908
of graph, 901
in-split
labeled, 908
of graph, 901
in-splitting map, 919
incidence matrix, 871
inclusion problem, 1150
incompressible pair, 496
incompressible set, 496
index of a partition, 319
initial state, 78
initializable, 643
injective morphism, 88
input alphabet, 78
integer
multiplicatively dependent, 859
multiplicatively independent, 859
integer and real arithmetic, 1083
intersection, 1068
invariant
measure, 883
inverse morphism, 77
irreducible
matrix, 871
substitution, 871
irreducible automaton, 833
irreducible shift, 915
isomorphism problem, 761, 799
isoperimetric inequality, 796, 799

J, 512
$\mathbf{J}_1$, 510
$\mathcal{J}^+$, 515
$\mathcal{J}$-trivial, 512
join, 537
Julia set, 812

k-block, 898
k-recognizable set, 858
Kazhdan group, 818
kernel, 81, 828, 831
k-kernel, 864
Kleene algebra, 678
left handed, 677
residuated, 681
right handed, 677
with domain, 679
with tests, 679
Kleene lattice, 679
Kleene monoid, 70
Kleene's theorem, 40, 44, 61, 65
Krieger automaton, 914
Krohn-Rhodes Theorem, 543
Kronecker's theorem, 859

label, 6
labeled
conjugacy, 908
in-merge, 908
in-split, 908
out-merge, 910
out-split, 910
lamplighter group, 804
language, 5
Σ_1, 526
accepted, *see* automaton
conjunctive, 698–700
linear, 701–702
constant term of –, 43
context-free, 697–698
denoted, *see* expression
dense, 528
Dyck, 701, 781
fragile, 711
group, 714
polynomial of, 714
left, 320
local, 25
non-counting, 460
of a tree automaton, 252
P-complete, 702
piecewise-testable, 511, 524
prime, 702, 711
quotient, 514
rational, 775
rational –, 42
recognisable –, 44

recognised, *see* automaton
recognizable, 7, 775
recognized, 7
recursive, 703, 706–712
recursively enumerable (r.e.), 706–712
right, 320
sequence, limit of, 691
slender, 528
sparse, 528
star-free, 454, 538
super-turtle, 471
turtle, 471
unambiguous, 470
with zero, 527
language equation, 690
explicit, 696
resolved, 696
strict, 696
language operation
computable, 706
continuous, 691–692
monotone, 692–693, 714
word-based, 693
lattice
generated by a set, 537
of languages, 518
Laurent series, 850
leaf
transitions, 223
learner, 355
learning
from given data, 363
in the limit, 355
MAT-learning, 360
through a minimally adequate teacher, 360
left
delay, 930
left language, 320
length, 5
length of a word, 76
letter
neutral, 456
letters, 4
limit space, 812
Lindenmayer system, 716
linear numeration basis, 860
linear ordering, 589
linear recurrence, 842
linear time computation, 834
linked pair, 649
Liouville number, 836
Liouville's inequality, 835
literal length, *see* expression
local automaton, 334
local automaton, 926
standard, 928
loop
complexity, 53
index, 53
Lyndon word, 338

Mal'cev product, 539
map
abelianisation, 871
edge in-merging, 902
edge in-splitting, 902
edge out-merging, 902
edge out-splitting, 902
in-merging, 920
in-splitting, 919
out-splitting, 920
Parikh, 871
sliding block, 898
mapping
automatic, 801
marker, 86
marking, 86
matrix
adjacency, 898
alphabetic, 908
block decomposition of –, 51
column division, 902
elementary equivalent, 903, 911
incidence, 871
irreducible, 871
primitive, 871
row division, 902
similar, 921
strong shift equivalent, 904, 911
symbolic elementary equivalent, 921
symbolic strong shift equivalent, 921

transition, 908
transition –, 44
matrix representation, 84
matrix embedding, 802
max-regular, 650
maximal growth, 876
word, 876
McNaughton's and Papert's Theorem, 535
McNaughton–Yamada algorithm, 45, 49, 65, 70
Mealy machine, 78
Mealy automaton, 801
bireversible, 803, 814–818
Cayley automaton, 813, 814
contracting, 807
dual, 803
nuclear, 806
reset machine, 813
reversible, 803, 813
measure
ergodic, 883
invariant, 883
uniquely ergodic, 883
membership game, 260
membership problem, 761
rational subset, 782
memory, block map, 898
merge of states, 334
mergeable states, 334
method
recursive, 45, 51, 65
state-elimination, 45, 47, 65, 70
system-solution, 45, 48, 65, 66
military order, 870
minimal
automaton, 913, 917
dynamical system, 882
nondeterministic automaton, 345
strongly connected component, 916
minimal automaton, 320
minimization, 1069
monadic second-order logic, 270
monadic second-order logic, 229
monoid, 4, 450
aperiodic, 512, 771
aperiodic, group-free, 451
automatic, 794
countably factorizable, 671
finitely factorizable, 661
finitely generated –, 60, 63
free, 5, 450
free profinite, 517
generating set of –, 60
graded –, 46, 63
idempotent and commutative, 510
inverse, 763, 771
Kleene –, 70
non-solvable, 451
partial, 661
rational –, 71
solvable, 451
syntactic, 450, 779
transition, 763, 771
monotone operation, *see* language operation, monotone
Moore
automaton slow, 324
Moore equivalence, 322
Moore algorithm
depth, 323
morphic composition, 77
morphic equivalence problem, 99
morphism, 76, 828
fixed point, 864
graph, 901
length multiplying, 516
non-erasing, 515, 525
of shifts, 898
prolongable, 864
recognizing, 37
semigroup, 904
uniform, 864
morphism of automata, 18
morphism of deterministic automata, 763
Morse–Hedlund's theorem, 865
MSO, 229, 270
-definable, 229
multidimensional automatic set, 831
multidimensional automaton, 831
multiplication (exterior), 63
multiplicative labelling, 589
multiplicatively

dependent, 859
independent, 859
multitape automaton, 79
Myhill-Nerode theorem, 353

NDD, 858, 1071
completion, 1079
construction, 1072, 1075, 1076
determinization, 1075
expressive power, 1071
operations, 1076
projection, 1078
quantification, 1077
size, 1074
negative examples, 356
Nerode congruence, 320
Nerode equivalence, 19
NFHA, 239
NFTA, 223
nilpotent group, 774, 800
Nivat's conjecture, 867
non-self dual, 636
non-self dual class, 637
non-uniformity, 448
nondeterministic automaton
minimal, 345
nonerasing morphism, 76
normalization, 860
normalized transducer, 80
nucleus of a Mealy automaton, 807
number
beta-number
β-number, 861
Parry, 861
Perron, 872
Pisot, 861
Number Decision Diagram, 1071
Number Decision Diagram, 858
numeration basis
Bertrand, 861
numeration base, 1069, 1081
numeration basis, 860
linear, 860
numeration system
abstract, 870

observation table, 354
closed, 354
consistent, 354
for words, 354
occurrence, 5
omega
ω-power, 517
operation
boolean, 453
star, 453
order
genealogical, 870
military, 870
radix, 870
order-type, 625
ordered semigroup, 917
order problem, 761, 799
ordinal number, 624
out-merge, 902
labeled, 910
out-split
labeled, 910
out-splitting map, 920
output alphabet, 78

p-group, 774, 804, 808
p-substitution, 885
Parikh map, 871
parity game, 258
Parry number, 861
partial signature, 335
partition, 319, 901
coarser, 319
refinement, 319
past of a state, 320
path, 6
accepting, 6
end, 6
final, 6
initial, 6
length, 6
origin, 6
successful, 6
path in a graph, 898
perfect field, 847
period, 865, 900
periodic

array, 885
dynamical system, 882
inside X, 885
locally periodic, 885
word, 865
periodic tiling, 89
Perron
number, 872
theorem, 871
Perron–Frobenius' theorem, 872
Pisot
number, 861
numeration system, 861
play, 257
pointed ω-semigroup, 649
polish space, 627
polynomial, 63
positional strategy, 258
positionally determined, 258
positive examples, 356
power series, *see* series
pre-fixed point, 673
prebase, 70
prefix, 76
prefix code, 477
maximal, 477
synchronized, 477
prefix tree acceptor, 353
prefix-closed, 352
prefix-suffix decomposition, 340
prefix metric, 772
preorder, 917
stable, 917
preperiod, 865
Presburger arithmetic, 867, 1072, 1077
decision, 1079
quantifiers, 1077
transformation, 1080
primitive
matrix, 871
substitution, 871
substitutive w.r.t. σ, 872
problem
Post correspondence, 782
problem, decision, 760–761, 789
conjugacy, 760
isomorphism, 761
membership, 761
order, 761
word, 760
generalized, 761
product, 4, 5, 451
2-sided semidirect, 543
deterministic, 540
prefix, 451
semidirect, 542
suffix, 451
unambiguous, 540
wreath, 542
profinite
$\mathcal{C}$-identity, 521
ordered, 521
distance, 516
equality, 520
equation, 518
inequality, 520
monoid, 517
program
branching, 453
super-turtle, 471
turtle, 470
progression
arithmetic, 859
projection, 76, 458, 630
projective hierarchy, 630
prolongable morphism, 864
prolongable morphism, 828
proper, *see* series
property
fellow traveller, 792
geometric, 791
(T), 818
pseudovariety, 510, 936
$\mathcal{C}$-pseudovariety of stamps, 522
of finite semigroups, 515
pumping lemma, 7, 832
[p-]pure subgroup, 771
pure induction, 682
purely substitutive word, 864

$\mathcal{QA}$, 515
QA, 515

quantale, 671
quasi-automatic function, 852
quasi-geodesic, 798
quasi-identity, 669
quasi-isometry, 781, 791
quasi-variety, 669, 679
quotient
    of a language, 57
    of a series, 67
    of an automaton, 54
quotient automaton, 320

radix order, 870
random walk, 807
    self-similar, 807
rank of a $\mathcal{D}$-class, 932
rational, 5
    closure, 45, 64
    element, 663
    expression, *see* expression, 667
    identities, *see* identities
    language, 42
    monoid, 71
    operations, 663
    series, 64
    subset, 60, 69
rational composition, 86
rational expression
    linear, 27
rational function, 80, 844
rational relation, 82
rational subset, 82
rational transduction, 79
rational constraint, 783
rational cross-section, 793
rational language, 775
reachability relation, 500
Real Number Automaton, 882
Real Vector Automaton, 882, 1082
realize, 84
recognisable
    language, 44
    subset, 61, 69
recognised, *see* automaton
recognizable, 37
    element, 663
recognizable set, 859
recognizable language, 775
recognizing, 37
recursive, *see* method
reduced automaton, 913
reduced expression, *see* expression
reduction of automata, 917
reduction relation, 630
reflexive-transitive closure, 658, 680
region, 1136
region automaton, 1138
region graph, 1138
regular, 5
    sequence, 881
    tree, 268
    tree language, 253
regular $\mathcal{D}$-class, 932
regular expression, *see* expression
regular tree grammar, 230, 242
Reiterman's Theorem, 522
representation, 65
    $\mathcal{S}$-, 870
    normal, 860
    U-, 860
reset threshold, 483
reset word, 475
residual automaton, 346
residually finite group, 773
residuation, 681
return word, 878
reversal
    automaton, 322
reversible Mealy automaton, 803, 813
rewriting system
    confluent, 761
        length-reducing etc., 779
Ridout's theorem, 838
right
    context, 913, 914
    delay, 930
right language, 320
ring, 4
RNA, 882
Road Coloring Conjecture, 495
Road Coloring Problem, 493
root, 251

Roth's theorem, 836
row division matrix, 902
run
  of a tree automaton, 251
  of an alternating tree automaton, 256
  of an NFHA, 239
  of an NFTA, 223
  of a TWA, 234
RVA, 882, 1082
  construction, 1084, 1087
  decision, 1090
  expressive power, 1083
  minimization, 1090
  operations, 1089
  projection, 1090
  size, 1085

saturated subset, 319
Schützenberger's Theorem, 538
Schreier graph, 768, 779, 789, 807
self dual, 636
self dual class, 637
self-similarity biset, 811
Semenov's theorem, 1071, 1083
semi-automaton, 324
semigroup, 4
  automatic, 794
  of an automaton, 801
  free, 5
  inverse, 783
  left-zero, 525
  ordered, 713, 917
  simple, 713
  stable, 526
  syntactic, 515, 918
  transition, 918
semigroup morphism, 904
semilattice, 510
semilattice order, 672
semilinear, 37
semiring, 4, 62, 656
  ω-continuous, 672
  ω-continuous iteration, 673
  ω-idempotent Conway, 657
  ω-idempotent iteration, 668
  Boolean, 4
  boolean, 657
  commutative, 656
  complete, 670
  complete iteration, 671
  completely idempotent, 670
  continuous, 672
  continuous iteration, 673
  Conway, 657
  Conway –, 63, 70
  countably complete, 670
  countably complete iteration, 671
  countably idempotent, 670
  dual, 662, 670
  formal series, 661, 669
  idempotent, 656
  iteration, 668
  matrix, 659, 669
  of binary relations, 657
  of languages, 657
  ordered, 672
  partial Conway, 657
  partial iteration, 668
  partial iterative, 658
  polynomial, 662
  quasi-Conway –, 63
  sum ordered, 672
  symmetric partial iterative, 662
  tropical, 657
  tropical/Min-Plus, 602
  zero-sum free, 658
Sénizergues, Géraud, 779, 780, 782
sentence, 229, 532
separated states, 321
separator symbol, 1081
sequence
  automatic, 864
sequential transducer, 78
serialization, 1070, 1082
series, 63, 661
  characteristic, 662
  coefficient in a –, 63
  constant term of –, 64
  denoted, *see* expression
  proper, 661
  proper –, 64
  rational, 663

rational –, 64
recognisable –, 65
recognizable, 663
support of –, 63
set
k-recognizable, 858
difference, 1068
k-recognizable, 866, 882
locally periodic, 885
periodic inside X, 885
projection, 1078
purely substitutive, 869
recognizable, 859
S-recognizable, 870
substitutive, 869
syndetic, 863
U-recognizable, 860
ultimately periodic, 859
set constraints, 695
shift space
forbidden factors, 897
shift transformation, 883
shift space, 897
almost finite type, 931
conjugacy, 899
edge, 898
entropy, 900
even, 897
finite type, 897
flow equivalent, 904
full, 897
golden mean, 897
higher block, 899
in-splitting, 920
morphism, 898
recognized by an automaton, 906
sofic, 897
transformation, 897
zeta function, 900
irreducible, 915
SHORT-RESET-WORD, 481
SHORTEST-RESET-WORD, 482
Σ_1-sentence, 513
sign header, 1070, 1082
sign symbol, 1070, 1081
signature
partial, 335
tree, 335
signature of a state, 334, 336
similar matrices, 921
simple
automaton, 337
simple transducer, 78
Skolem–Mahler–Lech theorem, 842
sliding block code, 883
sliding block map, 898
slow automaton, 324
slow automaton
for Moore, 331
for Hopcroft, 331
slow for Hopcroft, 324
slow for Moore, 324
small cancellation, 790, 795
sofic shift, 897
source of an edge, 898
spanning tree, 766
split, 591, 652
normalised, 591
Ramsey (for a multiplicative labelling), 592
splitter, 321
splitter in Hopcroft's algorithm, 325
spontaneous, *see* transition
stability relation, 495
stable, 68
stable pair, 495
stable preorder, 917
Stallings' construction, 768
amalgamated free products etc., 782
graph groups, 782
Stallings automaton, 764
Stallings construction, 763
stamp, 522
ordered, 522
quasi-aperiodic, 525
standard, *see* automaton
standard local automaton, 928
star, 36
star height
of a rational language, 70
of expression, 52
problem, 53, 70

star-free languages, 538
star-normal form
expression in –, 56, 70
of an expression, 56, 67
starable, 63
state, 78, 898
accessible, 6
coaccessible, 6
confluent, 335
final, 6
fusion, 334
future, 320
height, 336
initial, 6
merge, 334
mergeable, 334
partial signature, 335
past, 320
separated, 321
signature, 334, 336
state-elimination, *see* method
states, 6
strategy, 258
strictly connected component, 642
strong shift equivalent matrices, 904, 911, 921
strongly
connected component, minimal, 916
strongly connected component, 500
structure group, 932
Sturmian
tree, 333
sub-substitution, 877
subautomaton, 914
subautomaton rooted at a state, 320
subgroup
finitely generated, 760
fixed point, 774
index of a, 760
intersection, 770
normal, 769
[p-]pure, 771
quasi-convex, 797
subset automaton, 480
subshift, 883
generated, 883
subspace theorem, 839
substitution, 478, 864
block, 898
erasing, 873
good, 877
growing, 876
irreducible, 871
of finite length, 478
ω_α-substitution, 880
primitive, 871
projection, 873
sub-substitution, 877
substitutive w.r.t. $\mathcal{S}$, 872
substitutive w.r.t. σ, 872
substitutive word, 864
subtree, 222
subword, 511
successor, 867
suffix, 76
suffix-closed, 352
sum, 4
sum order, 672
superchain, 646
support, *see* series, 661
supremum, 641
surface group, 789
growth series, 791
symbol
contraction, 904
expansion, 904
symbolic
conjugacy of automata, 919
elementary equivalent matrices, 921
strong shift equivalent matrices, 921
symbolic representation, 1068
synchronized automaton, 913
synchronizing word, 913
synchronizing word of a code, 477
syndetic set, 863
syntactic, 649
congruence, 918
monoid, 21
morphism, 21
semigroup, 918
syntactic semigroup, 918
syntactic congruence, 22

syntactic graph, 932
syntactic monoid, 779
system-solution, *see* method

target of an edge, 898
test set, 94
Theorem
    Benois', 777
theorem
    Classification, 904
    Curtis–Lyndon–Hedlund, 898
    Decomposition, 903
    Franks', 905
    Kronecker, 859
    Perron, 871
    Perron–Frobenius, 872
Thompson, *see* automaton (of...)
Thue–Morse sequence, 827
Thue–Morse word, 865
tiling, 89
timed automaton, 1132
    deterministic, 1154
    diagonal-free, 1132
    with invariants, 1132
topological class, 629
topology
    pro-**V**, 773
transformation
    automatic, 801
transition
    matrix, 908
    matrix, 44
    semigroup, 918
    spontaneous, 54
transitions, 6, 78
    consecutive, 6
transition monoid, 763, 771
tree, 251
    signature, 335
    Sturmian, 333
tree-walking automaton, 234
tree automaton
    nondeterministic, 223
trellis automaton, *see* cellular automaton, one-way real-time
Tribonacci word, 872
trie, 335
trim, 9
trim automaton, 907
TWA, 234

U_1, 509
ultimately periodic, 859
    array, 885
    word, 865
unambiguous automaton, 273
unambiguous transducer, 83
unary term, 479
underlying graph (of an automaton), 480
uniform morphism, 76, 828
uniformity
    DLOGTIME, 448
    polynomial-time, 448
union, 1068
uniquely ergodic
    measure, 883
universality problem, 1150
universal cover, 788

valuation, 1131
variable
    free, 867
variety, 656, 682
    $\mathcal{C}$-, 521
        positive, 521
    generated by a set, 537
    positive, 516
variety of languages, 513
vertex, 898
    initial, 898
    ramified, 497
    terminal, 898
VH-group, 817
virtually free group, 781, 783

Wadge Borel determinacy, 635
Wadge class, 629
Wadge degree, 638
Wadge game, 634
Wadge hierarchy, 629
Wadge ordering, 629
waiting set in Hopcroft's algorithm, 325

Wang tile, 89
weak automaton, 1083
weak monadic second-order logic, 270
weakly branch group, 806, 808–809
  satisfies no identity, 809
well quasi-order (wqo), 712–715
well-ordered set, 851
winning condition, 258
winning region, 258
winning strategy, 258
wire, 448
WMSO, 270
word, 4
  accepted, 6
  almost periodic, 888
  automatic, 864
  characteristic, 865
  cyclically reduced, 762
  empty, 5
  maximal growth, 876
  ω_α-substitutive, 880
  periodic, 865
  primitive substitutive w.r.t. σ, 872
  reduced, 761
  return, 878
  substitutive, 864
    purely, 864
  substitutive w.r.t. $\mathcal{S}$, 872
  substitutive w.r.t. σ, 872
  Thue–Morse, 865
  Tribonacci, 872
  ultimately periodic, 865
word equation, 712
word problem over monoid, 451
word semigroup, 76
word-based operation, *see* language operation, word-based
word-hyperbolic group, 783, 797–800
  is biautomatic, 798
  linear isoperimetric inequality, 799
word metric, 790
word problem, 760, 790, 796, 799
  in automata groups, 806
  submonoid, 780
    context-free, 781
    rational, 780
wreath product principle, 542
wreath product, 802, 804

XML Schema, 242

zero in a semigroup, 932
zeta function, 900