

## Index of notation

$2^X$	entropy of an open cover, 302
family of all subsets, 431	
$A \Delta B$	Hölder constant, 402
symmetric difference of sets, 435	
$B(x, T, \varepsilon)$	entropy of a partition, 245
dynamical ball for flows, 318	
$B(x, \infty, \varepsilon)$	conditional entropy, 247
infinite dynamical ball, 325	
$B(x, n, \varepsilon)$	local Hölder constant, 402
dynamical ball, 262	
$B(x, r)$	set of invariant vectors, 66
ball of center $x$ and radius $r$ , 453	
$B^\delta$	mean information of an alphabet, 244
$\delta$ -neighborhood of a set, 36	
$C^*$	information of a symbol, 244
dual cone, 52	
$C^0(M)$	information function of a partition, 245
space of continuous functions, 50, 436, 457	
$C_+^0(M)$	space of essentially bounded functions, 471
cone of positive functions, 52	
$C^\beta(M)$	space of $p$ -integrable functions, 469
space of Hölder functions, 415	
$C^r(M, N)$	$P(f, \phi)$
space of $C^r$ maps, 462	pressure, 326
$C_n(\varphi, \psi)$	$P(f, \phi, \alpha)$
correlations sequence, 182	pressure relative to an open cover, 326
$D_l$	$P(x, \cdot)$
lower density, 59	transition probability, 190
$D_u$	$P_{ij}$
upper density, 59	transition probability, 191
$Df$	$R_\theta$
derivative of a map, 463	rotation on circle or torus, 16
$E(A, P)$	$S(f, \phi)$
conditional expectation, 152	pressure, via separated sets, 329
$E^*$	$S^1$
dual of a Banach space, 49	circle, 16
$G(f, \phi)$	$S^\perp$
pressure, via generating sets, 329	orthogonal complement, 474
$H(\alpha)$	$S^d$
	sphere of dimension $d$ , 461

$TM$	
tangent bundle, 463	
$T^1M$	
unit tangent bundle, 468	
$T_p M$	
tangent space at a point, 462	
$U_f$	
Koopman operator, 51	
$U_f^*$	
dual of the Koopman operator, 51	
$V(\mu, \Phi, \varepsilon)$	
neighborhoods in weak* topology, 36	
$V(v, \{g_1, \dots, g_N\}, \varepsilon)$	
neighborhoods in weak topology, 50	
$V^*(g, \{v_1, \dots, v_N\}, \varepsilon)$	
neighborhoods in weak* topology, 50	
$V_a(\mu, \mathcal{A}, \varepsilon)$	
neighborhoods in weak* topology, 37	
$V_c(\mu, \mathcal{B}, \varepsilon)$	
neighborhoods in weak* topology, 37	
$V_f(\mu, \mathcal{F}, \varepsilon)$	
neighborhoods in weak* topology, 37	
$V_p(\mu, \mathcal{B}, \varepsilon)$	
neighborhoods in pointwise topology, 44	
$V_u(\mu, \varepsilon)$	
neighborhoods in uniform topology, 44	
$\chi_B$	
characteristic function of a set, 440	
Diffeo $^r(M)$	
space of $C^r$ diffeomorphisms, 462	
Fix( $f$ )	
set of fixed points, 314	
GL( $d, \mathbb{R}$ )	
linear group, 78, 164, 466	
O( $d, \mathbb{R}$ )	
orthogonal group, 164	
SL( $d, \mathbb{R}$ )	
special linear group, 164, 466	
$\Sigma_A, \Sigma_P$	
shift of finite type, 193, 315, 316	
$\alpha \vee \beta$	
sum of open covers, 302	
$\alpha \prec \beta$	
order relation for open covers, 302	
$\alpha^n, \alpha^{\pm n}$	
iterated sum of an open cover, 303, 309, 310	
$L^1(\mu)$	
space of integrable functions, 445	
$\mathcal{M}(X)$	
space of measures, 50, 436	
$\mathcal{M}_1(M)$	
space of probability measures, 36	
$\mathcal{M}_1(f)$	
space of invariant probability measures, 116	
$\mathcal{M}_e(f)$	
space of ergodic probability measures, 116	
$\mathcal{P} \prec \mathcal{Q}$	
order relation for partitions, 247	
$\mathcal{P} \vee \mathcal{Q}$	
sum of partitions, 245	
$\mathcal{P}^n, \mathcal{P}^{\pm n}$	
iterated sum of a partition, 249, 252	
$\mathcal{U}^r(f, \varepsilon)$	
$C^r$ neighborhood of a map, 462	
$\delta_p$	
Dirac measure, 47	
div $F$	
divergence of a vector field, 20, 21	
degree( $f$ )	
degree of a map, 469	
$\lambda = (\lambda_\alpha)_\alpha$	
length vector, 201	
$\lambda_{\max}$	
largest Lyapunov exponent, 84	
$\lambda_{\min}$	
smallest Lyapunov exponent, 85	
$\mu \perp \nu$	
mutually singular measures, 451	
$\nu \ll \mu$	
absolutely continuous measure, 450	
$\partial I$	
left endpoint of an interval, 203	
$\partial \mathcal{P}$	
boundary of a partition, 259, 343	
$\mathbb{P}^d$	
projective space, 468	
$\rho(B)$	
spectral radius, 317	
spec( $L$ )	
spectrum of a linear operator, 477	
supess $\phi$	
essential supremum of a function, 471	
supp $\mu$	
support of a measure, 439, 477	
tanh	
hyperbolic tangent, 407	
$\tau(E, x)$	
mean sojourn time, 64	
$\theta(g_1, g_2)$	
projective distance, 405	
$\tilde{\varphi}$	
time average of a function, 72	
$\mathbb{T}^d$	
torus of dimension $d$ , 18, 461	
$\varphi^+$	
positive part of a function, 444	
$\varphi^-$	
negative part of a function, 444	

*Index of notation*

513

$\varphi_n$	$h(f, \alpha)$
orbital sum of a function, 326, 381	entropy relative to an open cover, 303
$\bigvee_\alpha \mathcal{U}_\alpha$	$h_\mu(f)$
$\sigma$ -algebra generated by a family, 279	entropy of a dynamical system, 250
$d$ -adic interval, 491	$h_\mu(f, \mathcal{P})$
$d(M)$	entropy relative to a partition, 250
Hausdorff dimension, 418	$h_\mu(f, \mathcal{P}, x)$
$e(\psi, x)$	entropy (local) at a point, 262
conditional expectation, 150	$h_\mu^\pm(f, \varepsilon, x)$
$f_*\mu$	entropy (local) at a point, 263
image of a measure, 45, 50	$m_d(M)$
$f_A$	$d$ -dimensional Hausdorff measure, 418
linear endomorphism of the torus, 111	$s(\phi)$
$g(\phi)$	topological entropy of flows, via separated sets, 319
topological entropy of flows, via generating sets, 319	$s(f)$
$g(f)$	topological entropy, via separated sets, 305
topological entropy, via generating sets, 305	$w = (w_\alpha)_\alpha$
$h(f)$	translation vector, 202
topological entropy, 303	

Cambridge University Press  
978-1-107-12696-1 - Foundations of Ergodic Theory  
Marcelo Viana and Krerley Oliveira  
[Index](#)  
[More information](#)

## Index

- 1-parameter group, 67
- $\sigma$ -additive function, 434, 477
- $\sigma$ -algebra, 431
  - Borel, ix, 432
  - generated, 279, 432
    - up to measure zero, 435
  - product, 104, 447, 448
  - $\sigma$ -finite measure, 9, 74, 433
- absolute continuity, 114, 438, 450
  - theorem, 133
- absolutely
  - continuous measure, 116, 450
    - summable series, 473
- action-angle coordinates, 123
- adding machine, 170
- additive
  - function, 433
  - sequence, 78
- adjoint linear operator, 476
- admissible sequence, 315
- affine function, 286
- algebra, 431
  - compact, 434
  - of functions, 459
    - separating, 459
  - generating, 11
  - of measures, 233
- almost
  - every point, 95, 446
  - everywhere, 446
    - convergence, 446
    - integrable system, 122
- alphabet, 201
- alternate form, 465
- Anosov
  - flow, 132
  - system, xi
  - theorem, 132
- aperiodic
  - stochastic matrix, 197
  - system, 29, 257
- approximate eigenvalue, 221
- approximation theorem, 435
- area form, 200
- arithmetic progression, 58
  - length, 58
- atlas
  - of class  $C^r$ , 460
  - compatible, 461
  - differentiable, 460
- atom, 457, 480
- atomic measure, 457
- Aubry–Mather set, 129
- automorphism
  - Bernoulli, 276
  - of a group, 164
  - Kolmogorov, 280, 283
  - Möbius, 416
- Avogadro constant, 333
- Baire space, 118, 120, 462, 466
- Banach space, 49, 469, 473
- Banach–Alaoglu theorem, 475
- Banach–Mazur theorem, 52
- barycenter of a measure, 287
- basin of a measure, 99, 353
- basis
  - dual, 465
  - Fourier, 474
  - Hammel, 474
  - Hilbert, 474
  - of neighborhoods, 36, 37, 439
    - countable, 439
  - of open sets, 439
    - countable, 439
  - of the topology, 439

- Bernoulli
  - automorphism, 276
  - measure, 191, 448
  - shift, 104, 191
- billiard, 134
  - corner, 134
  - dispersing, 139
  - semi-dispersing, 140
  - table, 134
- Birkhoff
  - ergodic theorem, 65, 70, 72, 74
  - ergodic theorem for flows, 77
  - multiple recurrence theorem, 29
  - normal form theorem, 127, 130
  - recurrence theorem, 8, 48
- Boltzmann
  - constant, 335
  - ergodic hypothesis, xi, 64, 120
- Boltzmann–Sinai ergodic hypothesis, 134
- Borel
  - $\sigma$ -algebra, ix, 432
  - measure, 453
  - normal theorem, 104
  - set, 432
- Borel–Cantelli lemma, 442
- bottom of a pile, 171
- boundary of a partition, 259, 343
- bounded
  - distortion, 102, 103, 108
  - linear functional, 475
  - linear operator, 475, 476
- Bowen–Manning formula, 381, 421
- branch (inverse), 355, 422
  - contracting, 355, 365, 366
- Brin–Katok theorem, 263
- bundle
  - cotangent, 125, 464
  - tangent, 125, 131
- Bunimovich
  - mushroom billiard, 140
  - stadium billiard, 140
- $C^0$  topology, 379
- $C^1$  topology, 379
- $C^r$  topology, 462
- Cantor
  - set, 418
  - substitution, 172
- Cauchy–Schwarz inequality, 470
- Cayley–Klein distance, 416
- Chacon
  - example, 220
  - substitution, 172
- Champernowne constant, 103
- change
  - of coordinates, 460
  - of variables formula, 297
- characteristic function, 440
- circle, 16
  - rotation, 16
- class  $C^r$ 
  - atlas, 460
  - diffeomorphism, 461
  - manifold, 460
  - map, 461
- closed differential form, 466
- coarser
  - cover, 302
  - partition, 146, 247
- cocycle, 84
- cohomological equation, 160
- cohomologous potentials, 332, 399
- cohomology relation, 332, 337
- commuting maps, 29
- compact
  - algebra, 434
  - group, 167
  - space, 434
- compactness theorem, 41
- compatible atlases, 461
- complete
  - measure, 435
  - measure space, 435
  - metric space, 456
  - metrizable space, 462
- completely metrizable space, 462
- completion of a measure space, 435
- complex measure, 436, 477
- concave function, 472
- condition
  - Keane, 203
  - twist, 124, 126, 127, 130
- conditional
  - entropy, 247
  - expectation, 150, 152, 264
  - probability, 144
- cone, 52, 404
  - dual, 52, 383
  - normal, 52
- configuration space, 333
- conformal
  - map, 421
  - repeller, 381, 421
- conjecture of entropy, 321
- conjugacy (topological), 215, 304
- connected space, 460
- conservative
  - flow, 20
  - map, 19

*Index*

517

- system, 49, 120
- constant
  - Avogadro, 333
  - Boltzmann, 335
  - Champernowne, 103
  - of expansivity, 260, 313
- continued fraction
  - expansion, 13
  - of bounded type, 116
- continuity
  - absolute, 114
  - at the empty set theorem, 434
  - from above theorem, 442
  - from below theorem, 442
  - set of a measure, 37
- continuous
  - function, 440
  - linear functional, 458, 475
  - linear operator, 475
  - map, 440
- contracting inverse branch, 355, 365, 366
- contraction, 308
- convergence
  - almost everywhere, 446
  - in distribution, 44
  - to equilibrium, 403
  - in  $L^2$ , 69
- convex
  - function, 472
  - hull, 422
  - set, 45
- convexity, 117, 286
- coordinate change, 460
- correlation, 181
  - decay, 208
- correlations sequence, 182
- cotangent
  - bundle, 125, 464
  - space, 125, 464
- countable basis
  - of neighborhoods, 439
  - of open sets, 439
- countable type shift, 228
- countably
  - additive function, 433
  - generated system, 228
- covariance
  - matrix, 231
  - sequence, 231
- cover, 418
  - coarser, 302
  - diameter, 307, 310, 418
  - finer, 302
  - open, 302, 434
- cross-ratio, 406
- cross-section, 89
- cube, 437
- cylinder, 448
  - elementary, 449
  - measurable, 55
  - open, 55
- decay of correlations, 208, 210
- decimal expansion, 10
  - ergodicity, 102
- decomposition
  - of Oseledets, 85
  - theorem of Hahn, 436
  - theorem of Lebesgue, 451
- degree of a map, 355, 365, 469
- Dehn twist, 487
- density
  - lower, 59
  - of a measure, 354, 451
  - point, 449
  - upper, 59, 61
  - zero at infinity, 189
- derivation theorem of Lebesgue, 449
- derivative, 463
  - exterior, 465
  - Radon–Nikodym, 354, 451
- diagonal, 31
- diameter
  - of a cover, 307, 310, 418
  - of a partition, 259, 452
- diffeomorphism, 460, 461
  - of class  $C^r$ , 461
- difference (orthogonal), 227
- differentiable
  - atlas, 460
  - manifold, 460
  - map, 461
- differential
  - form, 465
  - closed, 466
  - exact, 466
- dimension
  - Hausdorff, 418
  - Hilbert, 474
- Diophantine
  - number, 162
  - vector, 124
- Dirac
  - mass, 433
  - measure, 47, 433
- direct sum (orthogonal), 474
- discrete
  - spectrum, 213, 222
  - spectrum theorem, 234
  - topology, 106

- disintegration
  - of a measure, 144
  - theorem of Rokhlin, 147, 156
- dispersing billiard, 139
- distance, 453
  - associated with Riemannian metric, 467
  - Cayley–Klein, 416
  - flat on the torus, 101
  - hyperbolic, 416
  - invariant, 168
  - Poincaré, 416
  - projective, 405
- distortion, 102, 103, 108
  - lemma, 356
- distribution
  - function, 44
  - Gibbs, 335
- divergence of a vector field, 20, 21
- domain
  - fundamental, 88
  - of invertibility, 294
- dominated convergence theorem, 447
- dual
  - basis, 465
  - cone, 52, 383
  - linear operator, 51, 381
  - of a Banach space, 49, 471
  - of a Hilbert space, 475
- duality, 50, 209, 381, 471
- dynamical
  - ball, 262, 305
    - for a flow, 318
    - infinite, 325
  - decomposition theorem, 370
  - system, ix
- eigenvalue, 217
  - approximate, 221
  - multiplicity of, 217
- elementary cylinder, 449
- elliptic fixed point, 127, 128, 130
  - generic, 127
- endomorphism
  - of a group, 164
  - of the torus, 111
    - ergodic, 111
- energy
  - hypersurface, 121
  - of a state, 334
- entropy, xii
  - of a communication channel, 244
  - conditional, 247
  - conjecture, 321
  - of a dynamical system, 250
- formula, 398
- formula (Pesin), 273
- function, 258
- Gauss map, 269
- of a linear endomorphism, 270
- local, 262, 263
  - of a Markov shift, 268
  - of an open cover, 302
  - of a partition, 245
  - relative to a partition, 250
  - relative to an open cover, 303
  - semi-continuity, 258
  - of a state, 334
  - topological, 301, 303, 307
- equation
  - cohomological, 160
  - Hamilton–Jacobi, 121, 123, 127
- equidistributed sequence, 174
- equilibrium state, 302, 333, 345
- equivalence
  - ergodic, 161, 184, 213, 214, 233
    - invariant of, 215
  - spectral, 213, 216, 234
    - invariant of, 217
  - topological, 304
    - of flows, 320
- equivalent
  - measures, 14, 450
  - topologies, 37
- ergodic
  - decomposition theorem, 143
  - equivalence, 161, 184, 213, 214, 233
    - invariant of, 215
  - hypothesis, xi, 64, 120, 134
  - isomorphism, 214, 233
  - measure, 74
  - system, 93, 94
  - theorem
    - Birkhoff, 65, 70, 72, 74
    - Birkhoff for flows, 77
    - Kingman, 65, 78
    - Kingman for flows, 86
    - multiplicative, 85, 272
    - Oseledets, 85, 272
    - subadditive, 65, 78
    - subadditive for flows, 86
    - von Neumann, 65, 67, 74
    - von Neumann for flows, 70
    - von Neumann multiple, 190
- ergodicity
  - decimal expansion, 102
  - irrational rotation, 100, 101
  - linear endomorphism, 111
  - Markov shift, 194
- essential supremum, 471
- essentially bounded function, 471

- Euclidean space, 460
- exact differential form, 466
- exactness, 285
  - topological, 359
- example
  - Chacon, 220
  - Furstenberg, 160
- existence theorem, 35
  - for flows, 49
- expanding map, 26
  - of the interval, 361
  - on a manifold, 353
  - on a metric space, 362
- expansive map, 260, 313, 355, 366
  - two-sided, 313
- expansivity
  - constant, 260, 313
  - one-sided, 260
  - two-sided, 260
- expectation (conditional), 264
- exponential
  - decay of correlations, 210
  - decay of interactions, 335
  - map, 468
- extended real line, 432, 440
- extension
  - natural, 54, 57
  - multiple, 57
  - theorem, 434
  - of a transformation, 54
- exterior
  - derivative, 465
  - measure, 438
- extremal element of a convex set, 117
- factor, 253
  - topological, 304, 379
- Fatou lemma, 447
- Feigenbaum substitution, 172
- Fibonacci substitution, 172, 313
- filtration of Oseledets, 85
- finer
  - cover, 302
  - partition, 146, 247
- finite
  - Markov shift, 191
  - measure, 433
  - memory, 190, 199
  - signed measure, 436
- finitely additive function, 434
- first integral, 22, 121
- first-return
  - map, 5, 23, 88, 89
  - time, 5, 23, 89
- fixed point
  - elliptic, 127, 128, 130
  - generic, 127
  - hyperbolic, 128
  - non-degenerate, 127, 130
- flat distance on the torus, 101
- flow, ix, 2, 464
  - Anosov, 132
  - conservative, 20
  - geodesic, 131, 468
  - Hamiltonian, 121, 127
  - horocyclic, 283
  - suspension, 87
  - uniformly continuous, 319
  - uniformly hyperbolic, 132
- flows
  - Birkhoff ergodic theorem, 77
  - existence theorem, 49
  - Kingman ergodic theorem, 86
  - Poincaré recurrence theorem, 5
  - subadditive ergodic theorem, 86
  - topological entropy, 319, 320
  - von Neumann ergodic theorem, 70
- flux of a measure, 90, 92
- foliation
  - stable, 112, 113, 133
  - unstable, 112, 113, 133
- form
  - $k$ -linear, 465
  - alternate, 465
  - area, 200
  - differential, 465
    - closed, 466
    - exact, 466
  - linear, 465
  - symplectic, 124
  - volume, 21, 125
- formula
  - Bowen–Manning, 381, 421
  - change of variables, 297
  - entropy, 398
  - of entropy (Pesin), 273
  - Liouville, 20
  - Pesin, 398
  - Rokhlin, 294, 296, 361
- Fourier
  - basis, 474
  - series, 100, 111
- fractional part, 10
- free energy (Gibbs), 334
- frequency vector, 123
- Friedman–Ornstein theorem, 284
- function
  - $\sigma$ -additive, 433
  - $p$ -integrable, 469
  - affine, 286

- function (*cont.*)
  - characteristic, 440
  - concave, 472
  - continuous, 440
  - convex, 472
  - countably additive, 433
  - of distribution, 44
  - entropy, 258
  - essentially bounded, 471
  - finitely additive, 433
  - Hölder, 210, 402
  - information of a partition, 245
  - integrable, 445
  - invariant, 69, 94
  - locally constant, 209
  - locally integrable, 449
  - measurable, 440
  - of multiplicity, 480
  - quasi-periodic, 123
  - semi-continuous, 33
  - simple, 441
  - strongly affine, 293
  - uniformly quasi-periodic, 77
- functional
  - bounded, 475
  - continuous, 458
  - norm, 458
  - positive, 445, 458
    - over a cone, 52
  - tangent, 53
- functions algebra, 459
  - separating, 459
- fundamental domain, 88
- Furstenberg
  - example, 160
  - theorem, 160
- Furstenberg–Kesten theorem, 84
- gas
  - ideal, 136
  - lattice, 333
- Gauss map, 13, 24
  - entropy, 269
- Gaussian
  - measure, 231
  - shift, 231, 283
- generated
  - $\sigma$ -algebra, 279, 432
  - topology, 432
- generating
  - algebra, 11
  - partition, 256, 257
  - set, 305
    - for flows, 318
- generator
  - one-sided, 256
  - two-sided, 256
- geodesic, 468
  - flow, 131, 468
- Gibbs
  - distribution, 335
  - free energy, 334
  - state, 334, 336, 351, 380, 382
- golden ratio, 9, 180
- Gottschalk theorem, 162
- Grünwald theorem, 63
- Grassmannian manifold, 461
- Green–Tao theorem, 60
- group
  - 1-parameter, 67
  - automorphism, 164
  - compact, 167
  - endomorphism, 164
  - Lie, 163
  - linear, 164, 466
  - locally compact, 164
  - metrizable, 167
  - orthogonal, 164
  - special linear, 164, 466
  - topological, 163
- Haar
  - measure, 167
  - theorem, 165
- Hahn decomposition theorem, 436, 446
- Halmos–von Neumann theorem, 234
- Hamilton–Jacobi equation, 121, 123, 127
- Hamiltonian
  - flow, 121, 127
  - function, 121
  - non-degenerate, 123
  - system, 121
  - vector field, 22, 127
- Hammel basis, 474
- Hausdorff
  - dimension, 418
  - measure, 418
  - space, 36, 432
- hereditary property, 42
- heteroclinic
  - point, 486
- h*-expansive map, 314, 325, 349
- Hilbert
  - basis, 474
  - dimension, 474
  - space, 473
- Hindman theorem, 162
- Hölder
  - function, 210, 402

- inequality, 471, 472
- map, 454
- homeomorphism, 433
  - twist, 128
- homoclinic point, 128
- homomorphism of measure algebras, 233
- horocyclic flow, 283
- hyperbolic
  - distance, 416
  - fixed point, 128
  - matrix, 112
- hypersurface of energy, 121
- ideal gas, 136
- idempotent linear operator, 477
- identity
  - parallelogram, 476
  - polarization, 476
- image of a measure, 45, 50
- independent partitions, 245
- induced map, 24
- inequality
  - Cauchy–Schwarz, 470
  - Hölder, 471, 472
  - Jensen, 472
  - Margulis–Ruelle, 272
  - Minkowski, 470, 472
  - Tchebysheff–Markov, 451
  - Young, 472
- infinite
  - dynamical ball, 325
  - matrix, 231
  - measure, 8
- infinitesimal generator, 67
- information
  - of an alphabet, 244
  - function of a partition, 245
  - of a symbol, 244
- inner product, 470, 473
- integer part, 10
- integrability, 445
  - uniform, 86, 452
- integrable
  - function, 445
  - map, 126
  - system, 122
- integral, 444, 445
  - first, 121
  - with respect to a signed measure, 446
  - with respect to complex measure, 446
  - of a simple function, 444
- interval
  - $d$ -adic, 491
  - exchange, 92, 200
- irreducible, 202
  - in  $\mathbb{Z}$ , 58
- intrinsically ergodic map, 350
- invariant
  - distance, 168
  - of ergodic equivalence, 215
  - function, 69, 94
  - measure, 2, 45
  - set, 56, 94, 359
  - of spectral equivalence, 217
- inverse branch, 355, 422
  - contracting, 355, 365, 366
- invertibility domain, 294
- irrational rotation, 17
  - ergodicity, 100, 101
- irreducible
  - interval exchange, 202
  - stochastic matrix, 194
- isometrically isomorphic spaces, 458, 474
- isometry, 308
  - linear, 51, 476, 477
- isomorphism
  - ergodic, 214, 233
  - of measure algebras, 233
- iterate of a measure, 45, 50
- iterated sum
  - of an open cover, 303, 309, 310
  - of a partition, 249, 252
- Jacobian, 294
- Jacobs theorem, 287, 288
- Jensen inequality, 472
- Kač theorem, 5
- Kakutani–Rokhlin
  - lemma, 29
  - tower, 27, 28
- Keane
  - condition, 203
  - theorem, 204
- Kingman ergodic theorem, 65, 78
  - for flows, 86
- $k$ -linear form, 465
- Kolmogorov
  - automorphism, 280, 283
  - system, 279, 283
- Kolmogorov–Arnold–Moser theory, xi
- Kolmogorov–Arnold–Moser theorem, 124, 126
- Kolmogorov–Sinai
  - entropy, 250
  - theorem, 254
- Koopman operator, 51

- $L^2$  convergence, 69
- $L^\infty$  norm, 471
- $L^p$  norm, 470
- lattice
  - gas, 333
  - system, 333
  - state, 333
- leaf
  - stable, 113
  - unstable, 113
- Lebesgue
  - decomposition theorem, 451
  - derivation theorem, 449
  - exterior measure, 438
  - integral, 444, 445
  - measurable set, 236, 438, 443
  - measure, 437
    - on the circle, 17
  - number of an open cover, 307, 457
  - space, 233, 236, 238
  - spectrum, 213, 225, 283
  - rank of, 227, 230
- left
  - invariance, 167
  - translation, 164
- lemma
  - Borel–Cantelli, 442
  - distortion, 356
  - Fatou, 447
  - Kakutani–Rokhlin, 29
  - Riemann–Lebesgue, 232
  - shadowing, 367
  - Vitali, 450
  - Zorn, 31
- length
  - of an arithmetic progression, 58
  - of a curve, 467
  - vector, 201
- Levy–Prohorov metric, 39
- Lie group, 163
- lift
  - of an invariant measure, 56
  - of an invariant set, 56
- limit of a sequence of sets
  - inferior, 432
  - superior, 432
- linear
  - endomorphism of the torus, 111
  - form, 465
  - functional
    - bounded, 475
    - continuous, 458, 475
    - norm, 49, 458
    - positive, 445, 458
    - positive over a cone, 52
  - tangent, 53, 351
- group
  - special, 466
- isometry, 51, 476, 477
- operator
  - adjoint, 476
  - bounded, 475, 476
  - continuous, 475
  - dual, 51, 381
  - idempotent, 477
  - Koopman, 51
  - normal, 476, 479, 480
  - positive, 41, 51, 381
  - positive over a cone, 52
  - self-adjoint, 476, 477
  - spectrum, 477
  - unitary, 476, 479
- Liouville
  - formula, 20
  - measure, x, 121
  - theorem, 20, 21
- Lipschitz map, 454
- Livšic theorem, 380, 399
- local
  - chart, 460
  - coordinate, 460
  - diffeomorphism, 469
  - entropy, 262, 263
- local diffeomorphism, 272
- locally
  - compact group, 164
  - constant function, 209
  - integrable function, 449
  - invertible map, 294
- logistic map, 313
- lower density, 59
- Lusin theorem, 455, 457
- Lyapunov exponent, 85
- Möbius automorphism, 416
- manifold
  - differentiable, 460
  - Grassmannian, 461
  - leaf, 133
  - modeled on a Banach space, 460
  - of class  $C^r$ , 460
  - Riemannian, 467
  - stable, 113, 133
  - symplectic, 124
  - unstable, 113, 133
- Manneville–Pomeau map, 26
- map
  - $h$ -expansive, 314, 325, 349
  - conformal, 421
  - conservative, 19

*Index*

523

- continuous, 440
- decimal expansion, 10
- degree, 355, 365, 469
- derivative, 463
- differentiable, 461
- expanding, 26, 362
  - of the interval, 361
  - on a manifold, 353
- expansive, 260, 313, 355, 366
- exponential, 468
- first-return, 5, 23, 88, 89
- Gauss, 13, 24
- Hölder, 454
- induced, 24
- integrable, 126
- interval exchange, 92, 200
- intrinsically ergodic, 350
- Lipschitz, 454
- locally invertible, 294
- logistic, 313
- Manneville–Pomeau, 26
- measurable, 440
- minimal, 19, 101
- non-degenerate, 126
- of class  $C^r$ , 461
- Poincaré, 88, 89
- shift, 60, 104
- symplectic, 125
- time-1, 5
- topologically
  - exact, 359
  - mixing, 184
  - weak mixing, 220
- transitive, 106
- two-sided expansive, 313
- maps
  - topologically conjugate, 304
  - topologically equivalent, 304
- Margulis–Ruelle
  - inequality, 272
- Markov
  - measure, 191
  - shift, 191
    - entropy, 268
    - ergodic, 194
    - finite, 191
    - mixing, 197
  - mass distribution principle, 429
  - Masur–Veech theorem, 204
  - matrix
    - of covariance, 231
    - hyperbolic, 112
    - infinite, 231
    - positive definite, 231
    - stochastic, 191
- aperiodic, 197
- irreducible, 194
- symmetric, 231
- transition, 315
- maximal entropy measure, 345
- Mazur theorem, 53
- mean
  - information of an alphabet, 244
  - return time, 7
  - sojourn time, 64, 70
- measurable
  - cylinder, 55
  - function, 440
  - map, 440
  - partition, 142, 146
  - set, ix, 431
    - Lebesgue, 236, 438, 443
  - space, 431
- measure, x, 433
  - $\sigma$ -finite, 9, 74, 433
  - absolutely continuous, 116
  - algebra, 233
    - homomorphism, 233
    - isomorphism, 233
  - atomic, 457
  - barycenter of, 287
  - basin, 353
  - Bernoulli, 191, 448
  - Borel, 453
  - complete, 435
  - complex, 436, 477
  - density, 354
  - Dirac, 47, 433
  - ergodic, 74
  - exterior, 438
  - finite, 433
  - with finite memory, 190, 199
  - flux, 90, 92
  - Gaussian, 231
  - Haar, 167
  - Hausdorff, 418
  - infinite, 8
  - invariant, 2, 45
  - Lebesgue, 437
    - on the circle, 17
  - Liouville, x, 121
  - Markov, 191
  - non-atomic, 457
  - non-singular, 295, 452
  - of maximal entropy, 345
  - of probability, x, 433
  - physical, 360
  - positive, 436
  - product, 104, 447, 448
  - quotient, 143

- measure (*cont.*)
  - reference, 382–384
  - regular, 453
  - signed, 50, 436
    - finite, 436
  - space, 433
    - complete, 435
    - completion, 435
    - spectral, 477
  - stationary, 57, 190
  - suspension of, 91
  - tight, 456
- measures
  - equivalent, 14, 450
  - mutually singular, 118, 451
- metric
  - Levy–Prohorov, 39
  - Riemannian, 467
  - space, 453
    - complete, 456
- metrizable
  - group, 167
  - space, 39, 453
- minimal
  - map, 19, 101
  - set, 8, 159, 162
  - system, 157, 159, 204
- minimality, 19, 157, 204
- minimizing curve, 468
- Minkowski inequality, 470, 472
- mixing, 182
  - Markov shift, 197
  - weak, 218
- monkey paradox, 106
- monotone
  - class, 435
  - theorem, 435
  - convergence theorem, 447
- multiple
  - natural extension, 57
  - recurrence theorem
    - Birkhoff, 29
    - Poincaré, 29
  - von Neumann ergodic theorem, 190
- multiplicative ergodic theorem, 85, 272
- multiplicity
  - function, 480
  - of a Lyapunov exponent, 85, 86
  - of an eigenvalue, 217
- mushroom billiard, 140
- mutually singular measures, 118, 451
- natural extension, 54, 57
- multiple, 57
- negative
  - curvature, 132
  - part of a function, 444
- neighborhood
  - of a point, 439
  - of a set, 36
- non-atomic measure, 457
- non-degenerate
  - fixed point, 127, 130
  - Hamiltonian, 123
  - map, 126
- non-lacunary sequence, 29
- non-singular measure, 295, 452
- non-trivial
  - partition, 282
  - probability space, 279
- non-wandering
  - point, 34
    - super, 63
    - set, 34
- norm, 470, 473
  - $L^\infty$ , 471
  - $L^p$ , 470
    - of a linear functional, 49, 458
    - of a matrix, 78
    - of a measure, 436
    - of an operator, 168, 317, 320
    - uniform convergence, 457
- normal
  - cone, 52
  - linear operator, 476, 479, 480
  - number, 12, 103, 104
- normalized restriction of a measure, 142, 157
- number
  - Diophantine, 162
  - normal, 12, 103, 104
- odometer, 170
- one-sided
  - expansivity, 260
  - generator, 256
  - iterated sum
    - of an open cover, 302, 310
    - of a partition, 252
    - shift, 104
- open
  - cover, 302, 434
  - diameter, 307, 310
  - cylinder, 55
- operator
  - dual, 51, 381
  - Koopman, 51
  - norm, 168, 317, 320
  - normal, 476, 479, 480

*Index*

525

- positive, 41, 51, 381
  - over a cone, 52
- Ruelle–Perron–Frobenius, 381
- transfer, 209, 381
- orbital
  - average, 72
  - sum, 326, 381
- orthogonal
  - complement, 66, 474
  - difference, 227
  - direct sum, 474
  - group, 164
  - projection, 65
  - vectors, 474
- orthonormal set, 474
- Oseledets
  - decomposition, 85
  - ergodic theorem, 85, 272
  - filtration, 85
- Oxtoby–Ulam theorem, 120
- parallelogram identity, 476
- part
  - fractional, 10
  - integer, 10
  - negative, 444
  - positive, 78, 444
- partition, 6, 245, 452
  - boundary, 259, 343
  - defined by a cover, 40, 260
  - diameter, 259, 452
  - generating, 256, 257
  - measurable, 142, 146
  - non-trivial, 282
  - of  $\mathbb{Z}$ , 58
- partitions
  - coarser, 146, 247
  - finer, 146, 247
  - independent, 245
- path-connected space, 468
- periodic pre-orbit, 367
- permutation, 76
- Perron–Frobenius theorem, 192
- Pesin entropy formula, 273, 398
- phase transition, 333
- physical measure, 360
- pile
  - bottom, 171
  - simple, 171
  - top, 171
- piling method, 171
- $p$ -integrable function, 469
- Poincaré
  - distance, 416
  - first-return map, 88, 89
- last theorem, 128
- recurrence theorem, 4, 7
  - for flows, 5
  - multiple, 29
- Poincaré–Birkhoff fixed point theorem, 128
- point
  - of density, 449
  - heteroclinic, 486
  - non-wandering, 34
  - recurrent, 7
  - simultaneously recurrent, 29
  - super non-wandering, 63
  - transverse homoclinic, 128
- pointwise topology, 44
- polarization identity, 476
- Portmanteau theorem, 37
- positive
  - definite matrix, 231
  - linear functional, 445, 458
  - linear operator, 41, 51, 381
  - measure, 436
  - over a cone, 52
  - part of a function, 78, 444
- potential, 301, 326
  - cohomologous, 332, 399
- pre-orbit, 54, 367
  - periodic, 367
- pressure, 301, 325, 326
  - of a state, 334, 335
- primitive substitution, 172
- principle
  - least action (Maupertuis), 334
  - mass distribution, 429
  - variational, 334, 338
- probability
  - conditional, 144
  - measure,  $x$ , 433
  - space, 433
    - non-trivial, 279
    - standard, 233
    - transition, 190
- product
  - $\sigma$ -algebra, 104, 447, 448
  - inner, 470, 473
  - measure, 104, 448
  - of measures, 447
    - countable case, 448
    - finite case, 447
    - space, 447, 448
    - topology, 106, 442, 449
- Prohorov theorem, 42
- projection, 477
  - orthogonal, 65
  - stereographic, 461

- projective
  - distance, 405
  - quotient, 405
  - space, 468
- pseudo-orbit, 366
  - periodic, 367
- quasi-periodic function, 123
- quotient
  - measure, 143
  - projective, 405
- Radon–Nikodym
  - derivative, 354, 451
  - theorem, 450
- random variable, 44
- rank of Lebesgue spectrum, 227, 230
- rational rotation, 17
- rationally independent vector, 19, 203
- Rauzy–Veech renormalization, 207
- rectangle, 114, 437
- recurrent point, 7
  - simultaneously, 29
- reference measure, 382–384
- regular
  - measure, 453
  - value of a map, 466
- renormalization of Rauzy–Veech, 207
- repeller, 420
  - conformal, 381, 421
- residual set, 120, 462, 466
- return
  - first, 5
  - simultaneous, 30
  - time, 87, 88
  - time (mean), 7
- Riemann sum, 445
- Riemann–Lebesgue lemma, 232
- Riemannian
  - manifold, 467
  - metric, 467
  - submanifold, 467
- Riesz–Markov theorem, 436, 458
- right
  - invariance, 167
  - translation, 164
- Rokhlin
  - disintegration theorem, 147, 156
  - formula, 294, 296, 361
- root of a system, 286
- rotation, 16
  - on the circle, 16
  - irrational, 17
  - number, 127
  - rational, 17
- spectrum, 224
  - on the torus, 18
- Ruelle
  - inequality, 272
- Ruelle theorem, 336, 380
- Ruelle–Perron–Frobenius operator, 381
- Sard theorem, 467
- Schauder–Tychonoff theorem, 45
- section transverse to a flow, 89
- self-adjoint linear operator, 476, 477
- semi-continuity of the entropy, 258
- semi-continuous function, 33
- semi-dispersing billiard, 140
- separable
  - Hilbert space, 474
  - space, 39, 455, 458
- separated set, 305
  - for flows, 318
- separating
  - functions algebra, 459
  - sequence, 235
- sequence
  - additive, 78
  - admissible, 315
  - of correlations, 182
  - of covariance, 231
  - equidistributed, 174
  - non-lacunary, 29
  - separating, 235
  - subadditive, 78, 79
- series
  - absolutely summable, 473
  - Fourier, 100, 111
- set
  - Aubry–Mather, 129
  - Borel, 432
  - Cantor, 418
  - of continuity of a measure, 37
  - convex, 45
  - generating, 305
    - for flows, 318
  - invariant, 56, 94, 359
  - of invariant vectors, 66
  - Lebesgue measurable, 236, 438, 443
  - measurable, 431
  - minimal, 8, 159, 162
  - non-wandering, 34
  - orthonormal, 474
  - residual, 120, 462, 466
  - separated, 305
    - for flows, 318
  - strongly convex, 288
  - syndetic, 9, 162
  - tight, 42

*Index*

527

- transitive, 118
- with zero volume, 467
- shadowing lemma, 367
- Shannon–McMillan–Breiman theorem, 262
- shift
  - Bernoulli, 104, 191
  - of countable type, 228
  - of finite type, 193, 315
  - Gaussian, 231, 283
  - map, 60, 104
  - Markov, 191
    - entropy, 268
    - ergodic, 194
    - finite, 191
    - mixing, 197
  - multi-dimensional, 333
  - one-sided, 104
  - two-sided, 60, 104
- Sierpinski triangle, 429
- signed measure, 436
  - finite, 436
- simple
  - function, 441
  - pile, 171
- simultaneous return, 30
- simultaneously recurrent point, 29
- Sinai ergodicity theorem, 140
- Sinai, Ruelle, Bowen theory, xii
- skew-product, 53
- space
  - Baire, 118, 120, 462, 466
  - Banach, 49, 469, 473
  - compact, 434
  - completely metrizable, 462
  - of configurations, 333
  - connected, 460
  - cotangent, 125, 464
  - dual, 49, 471, 475
  - Euclidean, 460
  - Hausdorff, 36, 432
  - Hilbert, 473
    - separable, 474
  - Lebesgue, 233, 236, 238
  - measurable, 431
  - measure, 433
    - complete, 435
  - metric, 453
    - complete, 456
  - metrizable, 39, 453
    - complete, 462
  - path-connected, 468
  - probability, 433
    - non-trivial, 279
  - product, 447, 448
  - projective, 468
- separable, 39, 455, 458
- tangent at a point, 125, 462
- topological, 432
- topological vector, 45
- spaces
  - isometric, 458, 474
  - isomorphic, 458, 474
- special linear group, 164, 466
- specification, 374, 375
  - by periodic orbits, 375
- spectral
  - equivalence, 213, 216, 234
    - invariant of, 217
  - gap property, 209, 415
  - measure, 477
  - radius, 52, 317
  - representation theorem, 480
  - theorem, 479
- spectrum
  - discrete, 213, 222
  - Lebesgue, 213, 225
    - rank of, 227, 230
  - of a linear operator, 217, 477
  - of a rotation, 224
  - of a transformation, 217
- sphere of dimension  $d$ , 461
- spin system, 333
- stable
  - foliation, 112, 113, 133
  - leaf, 113, 133
  - manifold, 113, 133
  - set, 55
- stadium billiard, 140
- standard probability space, 233
- state
  - energy of, 334
  - entropy of, 334
  - equilibrium, 302, 333, 345
  - Gibbs, 334, 336, 351, 380, 382
  - of a lattice system, 333
  - pressure of, 334, 335
- stationary measure, 57, 190
- stereographic projection, 461
- stochastic matrix, 191
  - aperiodic, 197
  - irreducible, 194
- Stone theorem, 67
- Stone–Weierstrass theorem, 459
- stronger topology, 37
- strongly
  - affine function, 293
  - convex set, 288
- subadditive
  - ergodic theorem, 65, 78
    - for flows, 86

- subadditive (*cont.*)
  - sequence, 78, 79
- subcover, 302, 434
- submanifold, 461
  - Riemannian, 467
- substitution, 171, 173
  - Cantor, 172
  - Chacon, 172
  - Feigenbaum, 172
  - Fibonacci, 172, 313
  - primitive, 172
  - Thue–Morse, 172
- sum
  - direct orthogonal, 474
  - of a family of subspaces, 473
  - of a family of vectors, 473
  - of open covers, 302
  - orbital, 326, 381
  - of partitions, 245
  - Riemann, 445
- super non-wandering point, 63
- support
  - of a measure, 439
  - of a spectral measure, 477
- suspension
  - flow, 87
  - of a measure, 88, 91
  - of a transformation, 87
- symmetric
  - difference, 435
  - matrix, 231
- symplectic
  - form, 124
  - manifold, 124
  - map, 125
- syndetic set, 9, 162
- system
  - almost everywhere invertible, 240
  - almost integrable, 122
  - Anosov, xi
  - aperiodic, 29, 257
  - conservative, 49, 120
  - countably generated, 228
  - with discrete spectrum, 213, 222
  - ergodic, 93, 94
  - with finite memory, 190, 199
  - Hamiltonian, 121
  - integrable, 122
  - Kolmogorov, 279, 283
  - lattice, 333
    - state, 333
  - with Lebesgue spectrum, 213, 225, 283
  - Lebesgue spectrum
    - rank of, 227, 230
- minimal, 157, 159, 204
- mixing, 182
- root, 286
- spin, 333
- totally dissipative, 49
- uniquely ergodic, 157
- weak mixing, 185, 218
- Szemerédi theorem, 59, 61
- tangent
  - bundle, 125, 131, 463
  - unit, 131, 468
- linear functional, 53, 351
- space at a point, 125, 462
- Tchebysheff–Markov inequality, 451
- theorem
  - absolute continuity, 133
  - Anosov, 132
  - approximation, 435
  - Banach–Alaoglu, 50, 475
  - Banach–Mazur, 52
  - Birkhoff
    - ergodic, 65, 70, 72, 74
    - ergodic for flows, 77
    - multiple recurrence, 29
    - normal form, 127, 130
    - recurrence, 8, 48
  - Borel normal, 104
  - Brin–Katok, 263
  - compactness, 41
  - continuity
    - from above, 442
    - from below, 442
    - at the empty set, 434
  - discrete spectrum, 234
  - disintegration, 147
  - dominated convergence, 447
  - dynamical decomposition, 370
  - ergodic decomposition, 143
  - existence of invariant measures, 35
    - for flows, 49
  - extension of measures, 434
  - Friedman–Ornstein, 284
  - Furstenberg, 160
  - Furstenberg–Kesten, 84
  - Gottschalk, 162
  - Grünwald, 63
  - Green–Tao, 60
  - Haar, 165
  - Hahn decomposition, 436
  - Halmos–von Neumann, 234
  - Hindman, 162
  - Jacobs, 287, 288
  - Kač, 5
  - Keane, 204

*Index*

529

- Kingman ergodic, 65, 78
  - for flows, 86
- Kolmogorov–Arnold–Moser, 124, 126
- Kolmogorov–Sinai, 254
- Lebesgue
  - decomposition, 451
  - derivation, 449
- Liouville, 20, 21
- Livšic, 380, 399
- Lusin, 455, 457
- Masur–Veech, 204
- Mazur, 53
- monotone class, 435
- monotone convergence, 446
- multiplicative ergodic, 85, 272
- Oseledets, 85, 272
- Oxtoby–Ulam, 120
- Perron–Frobenius, 192
- Poincaré
  - multiple recurrence, 29
  - recurrence, 4, 7
- Poincaré–Birkhoff fixed point, 128
- Portmanteau, 37
- Prohorov, 42
- Radon–Nikodym, 450
- Riesz–Markov, 436, 458
- Rokhlin, 147, 156
- Ruelle, 336, 380
- Sard, 467
- Schauder–Tychonoff, 45
- Shannon–McMillan–Breiman, 262
- Sinai ergodicity, 140
- spectral, 479
- spectral representation, 480
- Stone, 67
- Stone–Weierstrass, 459
- subadditive ergodic, 65, 78
  - for flows, 86
- Szemerédi, 59, 61
- Tychonoff, 106
- van der Waerden, 58, 60
- von Neumann ergodic, 65, 67, 74
  - for flows, 70
  - multiple, 190
- Weyl, 174
- Whitney, 467
- Thue–Morse substitution, 172
- tight
  - measure, 456
  - set of measures, 42
- time
  - average, 72
  - constant of a subadditive sequence, 86
- of first return, 5, 23, 89
- mean sojourn, 64, 70
- of return, 87, 88
- time-1 map, 5
- top of a pile, 171
- topological
  - conjugacy, 215, 304
  - entropy, 301, 303, 307
    - for flows, 319, 320
  - equivalence, 304
    - of flows, 320
  - factor, 304, 379
  - group, 163
  - space, 432
  - vector space, 45
  - weak mixing, 220
- topologically
  - conjugate maps, 304
  - equivalent maps, 304
  - exact map, 359
  - mixing map, 184
  - weak mixing map, 220
- topology, 432
  - $C^0$ , 379
  - $C^1$ , 379
  - $C^r$ , 462
  - defined by
    - a basis of neighborhoods, 36
    - a distance, 453
  - discrete, 106
  - generated, 432
  - pointwise, 44
  - product, 106, 442, 449
  - stronger, 37
  - uniform, 44
  - uniform convergence, 379
  - weak, 50, 475
  - weak\*, 36, 50, 475
  - weaker, 37
- torus, 18
  - of dimension  $d$ , 110, 461
  - rotation, 18
- total variation, 436
- totally dissipative system, 49
- tower, 27
  - Kakutani–Rokhlin, 28
- transfer operator, 209, 381
- transition
  - matrix, 315
  - phase, 333
  - probability, 190
- transitive
  - map, 106
  - set, 118
- transitivity, 118

530

*Index*

- translation
  - in a compact group, 308
  - left, 164
  - right, 164
  - vector, 202
- transversality, 466, 469
- transverse
  - homoclinic point, 128
  - section, 89
- twist
  - condition, 124, 126, 127, 130
  - Dehn, 487
  - homeomorphism, 128
- two-sided
  - expansivity, 260
  - generator, 256
  - iterated sum
    - of a partition, 252
    - of an open cover, 309, 310
  - shift, 60, 104
- Tychonoff theorem, 106
- uniform
  - convergence norm, 457
  - integrability, 86, 452
  - topology, 44
- uniformly
  - continuous flow, 319
  - hyperbolic flow, 132
  - quasi-periodic function, 77
- unique ergodicity, 157
- unit
  - circle, 16
  - tangent bundle, 131, 468
- unitary linear operator, 476, 479
- unstable
  - foliation, 112, 113, 133
  - leaf, 113, 133
- manifold, 113, 133
- up to measure zero, 435
- upper density, 59, 61
- van der Waerden theorem, 58, 60
- variation, 436
- variational principle, 334, 338
- vector
  - Diophantine, 124
  - field, 464
    - Hamiltonian, 22, 127
  - frequency, 123
  - length, 201
  - rationally independent, 19, 203
  - translation, 202
- Vitali
  - lemma, 450
- volume
  - element, 131
  - form, 21, 125
  - induced by a Riemannian metric, 131, 165
- von Neumann ergodic theorem, 65, 67, 74
  - for flows, 70
  - multiple, 190
- weak
  - mixing, 185, 218
  - topology, 50, 475
- weak\* topology, 36, 50, 475
- weaker topology, 37
- Weyl theorem, 174
- Whitney theorem, 467
- word, 243
- Young inequality, 472
- zero volume set, 467
- Zorn lemma, 31