

Index

- 2-regular segment, 252
 $GL(2, \mathbb{F})$, 482
 center of —, 486
 conjugacy classes of —, 482
 spherical function for —, 515
 $GL(2, \mathbb{F}_q)$, 488
 Borel subgroup of —, 488
 character table for —, 529
 conjugacy classes of —, 489
 cuspidal representation of —, 502
 decomposition of tensor products of
 representations of —, 540
 Gelfand-Graev character for —, 527
 induced representations from — to
 $GL(2, \mathbb{F}_q^m)$, 533
 one-dimensional representations of —, 498
 order of —, 488
 parabolic induction for —, 494
 representation theory of the Borel subgroup
 of —, 492
 Whittaker model for —, 513
p-group, 22
p-primary group, 22
- Abel formula of summation by parts, 77
 Abelian
 — algebra, 55, 362
 automorphism of a finite — group, 27
 Cauchy theorem for — groups, 20
 character of an — group, 50
 convolution on the group algebra of an —
 group, 54
 dual of an — group, 50
 endomorphism of a finite — group, 26
 Fourier transform on an — group, 53
 invariant factors decomposition of a finite
 — group, 18
 primary component of an — group, 22
 primary decomposition of a finite — group,
 21, 22
- action
 — of a finite group on a finite set, 372
 diagonal —, 377
 doubly transitive —, 379
 transitive —, 372
- adapted basis, 397
 additive character of \mathbb{F}_q , 197
 principal —, 198
- adjacency
 — matrix, 238
 — operator, 238
- adjacent vertex, 236
- adjoint
 — in $L(G)$, 363
 — operator, 345
 — representation, 380
- adjugate matrix, 36
- affine group
 — over \mathbb{F}_q , 374, 426
 — over $\mathbb{Z}/n\mathbb{Z}$, 432
 — over a field, 487
- algebra, 55, 361
 *- —, 362
 — *-anti-homomorphism, 363
 — *-anti-isomorphism, 363
 — *-homomorphism, 362
 — *-isomorphism, 363
 Abelian —, 55, 362
 anti-automorphism of an —, 467
 center of an —, 362
 commutative —, 55, 362
 convolution on the group — of an Abelian
 group, 54
 group —, 363
 Hecke —, 462
 involutive —, 362

- algebra (*cont.*)
 involutive anti-automorphism of an —, 467
 sub- —, 361
 unital —, 55, 362
- algebraic
 — element, 171
 — extension, 173
 — number, 65
- algorithm
 Cooley-Tukey —, 129, 161, 162
 decimation in frequency of the
 Cooley-Tukey —, 162
 decimation in time form of the
 Cooley-Tukey —, 162
 Diaconis and Rockmore —, 397
 parallel form of the Cooley-Tukey —, 162
 Rader —, 159
 Rader-Winograd —, 158
 vector form of the Cooley-Tukey —, 162
- Alon-Boppana theorem, 299
- Alon-Boppana-Serre theorem, 298
 Nilli's proof, 305
- Alon-Milman theorem, 287
- Alon-Schwartz-Shapira theorem, 320
- ambivalent group, 468
- anti-automorphism of a group, 466
 involutive —, 467
- anti-automorphism of an algebra, 467
 involutive —, 467
- Auslander-Feigh-Winograd theorem, 230
- automorphism of a finite Abelian group, 27
- Bézout identity, 4
 generalized —, 5
- Bessel
 — function for $GL(2, \mathbb{F}_q)$, 515
 — vector, 515
- bicolorable graph, 246
- bidual of a group, 52
- bipartite graph, 245
 complete —, 247
 partite sets of a —, 245
- block diagonal power of a matrix, 148
- Borel subgroup
 — of $GL(2, \mathbb{F})$, 486
 — of $GL(2, \mathbb{F}_q)$, 488
 representation theory of the — of
 $GL(2, \mathbb{F}_q)$, 492
- boundary of a set of vertices in a graph, 284
- Bruhat decomposition, 487
- Bump-Ginzburg criterion, 468
- Burnside lemma, 376
- canonical form of a matrix, 482
 Jordan —, 485
 rational —, 485
- Cartan subgroup, 488
- Cartesian product of graphs, 258
- Cauchy
 — theorem for (not necessarily Abelian)
 groups, 21
 — theorem for Abelian groups, 20
- Cayley graph, 280
- Cayley-Hamilton Theorem, 484
- center
 — of $GL(2, \mathbb{F})$, 486
 — of a group, 431
 — of an algebra, 362
- central function, 364
- centralizer subgroup, 487
- character
 — of \mathbb{Z}_n , 49
 — of a representation, 355
 — of an Abelian group, 50
 — table for $GL(2, \mathbb{F}_q)$, 529
- additive — of \mathbb{F}_q , 197
- conjugate —, 202
- decomposable —, 201
- Dirichlet —, 84
- dual orthogonality relations for —s of \mathbb{Z}_n ,
 50
- dual orthogonality relations for —s of a
 group, 370
- dual orthogonality relations for —s of an
 Abelian group, 52
- exceptional —, 523
- fixed point — formula, 375
- Fourier transform of a —, 382
- Frobenius — formula, 405
- Gelfand-Graev —, 527
- indecomposable —, 201
- multiplicative — of \mathbb{F}_q , 199
- multiplicative — of $\mathbb{Z}/m\mathbb{Z}$, 84
- permutation —, 375
- principal Dirichlet —, 85
- real Dirichlet —, 87
- characteristic
 — function, 47
 — of a field, 171
 — polynomial of \mathcal{F} , 116
 — polynomial of \mathcal{F}^2 , 103
 — polynomial of a matrix, 484
 — subgroup, 431
- Chebotarëv theorem, 68
- Chebyshev polynomials of the second kind,
 547
 modified —, 548, 549
- Cheeger constant, 284
- Chevalley theorem, 227
- Chinese remainder
 — map, 138
 — theorem, 9, 13
- circulant matrix, 58
 elementary permutation —, 147

- class function, 364
- Clebsch graph, 243
- closed path, 237
- coefficient
 - (matrix) — of a representation, 351
 - Gamma —, 525
- coloring
 - of a graph, 243
 - of an edge, 243
- combinatorial Laplacian, 286
- commutant
 - of one representation, 349, 390
 - of two representations, 349
- commutative algebra, 55, 362
- companion matrix of a monic polynomial, 191
- complement of a graph, 242
- complete graph, 247, 271, 292
 - lamplighter on the —, 270
- composite bijection permutation, 136
- composition of paths, 237
- congruence permutation
 - elementary —, 135
 - product —, 135
- conjugate
 - character, 202
 - of an element in \mathbb{F}_q , 196
 - representation, 380
- conjugation homomorphism, 280
- connected
 - components of a graph, 237
 - graph, 237
- convolution, 363
 - formula for the spherical Fourier transform, 478
 - operator, 365
 - on $L(A)$, 56
 - on the group algebra of an Abelian group, 54
- Cooley-Tukey algorithm, 129, 161, 162
 - decimation in frequency of the —, 162
 - decimation in time form of the —, 162
 - parallel form of the —, 162
 - vector form of the —, 162
- core matrix, 159, 228
- Courant-Fischer min-max formula, 304
- Curtis and Fossium basis, 464
- cuspidal representation, 502
- cycle
 - in a graph, 237
 - discrete — graph, 250
- cyclic group, 48
 - endomorphism of a finite —, 30
- decomposable character, 201
- decomposition
 - of a representation, 344
- invariant factors — of a finite Abelian group, 18
 - primary — of a finite Abelian group, 21, 22
- degree
 - of a field extension, 171
 - of a polynomial, 168
 - of a representation, 344
 - of a regular graph, 236
 - of a vertex, 236
- derived subgroup, 431, 486
- Diaconis and Rockmore, 397, 398
- diagonal
 - action, 377
 - matrix of twiddle factors, 153
 - operator, 361
 - block — power of a matrix, 148
- diameter of a finite graph, 237
- differential operator, 68
- dihedral group, 359
- dimension of a representation, 344
- Dirac function, 46
- direct sum of representations, 344
- directed graph, 236
- Dirichlet
 - L -function, 89
 - character, 84
 - double summation method, 87
 - form, 286
 - formula, 89
 - series, 77
 - theorem $L(1, \chi) \neq 0$, 95
 - theorem on primes in arithmetic progressions, 99
 - principal — character, 85
 - real — character, 87
- discrete
 - circle, 250
 - cycle graph, 250
 - Fourier transform (DFT), 53, 59
 - Fourier transform (DFT) revisited, 443, 445
 - Gauss-Schur theorem on the trace of the — Fourier transform (DFT), 116
- distance
 - geodesic — in a graph, 237
 - Hamming —, 248, 264
- Dodziuk theorem, 288
- domain
 - integral —, 167
 - principal ideal —, 168
 - unique factorization — (UFD), 169
- doubly transitive action, 379
- dual
 - group of \mathbb{F}_q , 197
 - group of \mathbb{F}_q^* , 199
 - group of an Abelian group, 50
 - of a finite dimensional vector space, 380

- dual (*cont.*)
 — of a finite group, 347
 — orthogonality relations for characters of \mathbb{Z}_n , 50
 — orthogonality relations for characters of a group, 370
 — orthogonality relations for characters of an Abelian group, 52
- edge
 — coloring, 243
 — of a graph, 235
 multiple —, 235
 oriented — of a graph, 236
- eigenidentities, 152
 tensor form of the —, 153
- Eisenstein criterion, 63
- element
 algebraic —, 171
 primitive — of a Galois field, 176
- elementary congruence permutation, 135
- endomorphism
 — of a finite Abelian group, 26
 — of a finite cyclic group, 30
- equivalent representations, 344
- Erdős' proof of Euler theorem
 $\sum_{p \text{ prime}} \frac{1}{p} = +\infty$, 98
- Euclid's proof of the infinitude of primes, 6
- Euclidean algorithm, 5
- Euler
 — identity, 31
 — product formula, 82
 — theorem $\sum_{p \text{ prime}} \frac{1}{p} = +\infty$, 97
 — theorem $\sum_{p \text{ prime}} \frac{1}{p} = +\infty$ (Erdős' proof), 98
 — totient function, 7
- Euler-Mascheroni constant, 82
- exceptional character, 523
- expander, 309, 310
 — via zig-zag products, 338
 Margulis —, 319
- exponential set, 257
- extension, 171
 algebraic —, 173
 degree of a field —, 171
 finite —, 171
 Galois group of an —, 174
 infinite —, 171
 norm of a field —, 187
 quadratic —, 173
 trace of a field —, 187
- faithful representation, 344
- fast Fourier transform (FFT), 129
 — over a noncommutative group, 397
 — revisited, 447, 455
- algorithmic aspects of the —, 161
 matrix form of the —, 151
- Fermat
 — identity, 31
 — little theorem, 9
- field, 168
 — extension, 171
 Galois —, 178, 181
 primitive element of a Galois —, 176
 splitting — of a polynomial, 174
 sub—, 171
- finite
 — extension, 171
 — graph, 236
- fixed point character formula, 375
- formula
 Abel — of summation by parts, 77
 Courant-Fischer min-max —, 304
 Dirichlet —, 89
 Euler product —, 82
 Frobenius character —, 405
 Gauss —, 116
 Mackey — for invariants, 414, 417
 Parseval — for \mathbb{Z}_n^2 , 312
 Parseval — for an Abelian group, 54
 Plancherel — for \mathbb{Z}_n^2 , 312
 Plancherel — for a finite group, 371
 Plancherel — for an Abelian group, 54
 Plancherel — for the spherical Fourier transform, 478
 Poisson summation —s, 60
- Fourier
 — transform, 367
 — coefficient, 53
 — inversion formula, 368
 — inversion formula for an Abelian group, 53
 — transform of a character, 382
 — transform on an Abelian group, 53
 — matrix of \mathbb{F}_q , 227
- convolution formula for the spherical — transform, 478
- discrete — transform (DFT), 53, 59
- discrete — transform (DFT) revisited, 443, 445
- fast — transform (FFT), 129
- fast — transform (FFT) revisited, 447, 455
- Gauss-Schur theorem on the trace of the discrete — transform (DFT), 116
- inverse — transform, 370
- inversion formula for the spherical — transform, 477
- normalized — transform, 53
- Plancherel formula for the spherical — transform, 478
- spherical — transform, 477

- Frobenius
 — automorphism, 177
 — character formula, 405
 — reciprocity law, 409
 — reciprocity law (other side), 411
 — reciprocity law for one-dimensional representations, 412
- function
 Bessel — for $GL(2, \mathbb{F}_q)$, 515
 central —, 364
 characteristic —, 47
 class —, 364
 Dirac —, 46
 Dirichlet L —, 89
 Euler totient —, 7
 inflation of a —, 59
 Riemann zeta —, 82
 spherical —, 469
 spherical — for $GL(2, \mathbb{F}_q)$, 515
- fundamental theorem of arithmetic, 5
- Galois
 — field, 178, 181
 — group of an extension, 174
- Gamma coefficient, 525
- Gauss
 — formula, 116
 — law of quadratic reciprocity, 127
 — law of quadratic reciprocity (second proof), 183
 — sum, 126, 210
 — theorem on cyclicity of $\mathcal{U}(\mathbb{Z}/n\mathbb{Z})$, 35
 — totient function theorem, 8
 — lemma, 64
- Gauss-Schur theorem on the trace of the DFT, 116
- Gelfand pair, 466
 symmetric —, 468
 weakly symmetric —, 468
- Gelfand-Graev character, 527
- general radix identity, 154
- generalized quaternion group, 360
- generalized Winograd's method, 157
- geodesic distance in a graph, 237
- Good's method, 158
- graph
 d -edge-colorable —, 275
 — edge, 235, 236
 — isomorphism, 237
 — multiple edge, 235
 — vertex, 235, 236
 primitive —, 242
 bicolorable —, 246
 bipartite —, 245
 boundary of a set of vertices in a —, 284
 Cartesian product of —s, 258
 Cayley —, 280
- Cheeger constant of a —, 284
- Clebsch —, 243
- complement of a —, 242
- complete —, 247, 292
- complete bipartite —, 247
- connected —, 237
- connected component of a —, 237
- degree of a regular —, 236
- diameter of a finite —, 237
- directed —, 236
- directed — isomorphism, 237
- discrete cycle —, 250
- expander —, 309, 310
- finite —, 236
- geodesic distance in a —, 237
- Hamming —, 264
- isoperimetric constant of a —, 284
- lamplighter —, 268
- lexicographic product of —s, 260
- Margulis —, 319
- non-oriented square of a —, 338
- Paley —, 308
- partite sets of a bipartite —, 245
- Petersen —, 243
- Ramanujan —, 307
- regular —, 236
- replacement product of —s, 275
- simple —, 235
- spectral gap of a —, 292
- spectrum of a —, 238
- strongly regular —, 241
- subgraph of a —, 236
- tensor product of —s, 259
- triangular —, 242
- undirected —, 235
- wreath product of —s, 267
- zig-zag product of —s, 277
- greatest common divisor, 5
- Green-Tao theorem, 100
- group
 p - —, 22
 p -primary —, 22
 — $GL(2, \mathbb{F}_q)$, 488
 — $GL(h, \mathbb{F}_p)$, 40
 — algebra, 363
 — of units of a unital ring, 28
 affine — over \mathbb{F}_q , 374, 426
 affine — over $\mathbb{Z}/n\mathbb{Z}$, 432
 affine — over a field, 487
 ambivalent —, 468
 anti-automorphism of a —, 466
 bidual of a —, 52
 center of a —, 431
 characteristic subgroup of a —, 431
 cyclic —, 48
 derived subgroup of a —, 431
 dihedral —, 359

- group (*cont.*)
 dual — of an Abelian group, 50
 Galois — of an extension, 174
 generalized quaternion —, 360
 Heisenberg — over \mathbb{F}_q , 457
 Heisenberg — over $\mathbb{Z}/n\mathbb{Z}$, 437
 inertia —, 421
 involutive anti-automorphism of a —, 467
 solvable —, 486
 symmetric —, 349
- Hamming
 — distance, 248, 264
 — graph, 264
- Hankel matrix, 159
- Hasse-Davenport identity, 216
- Hecke
 — algebra, 462
 — operator, 295
 — relations, 296
 commutative — algebra, 466
 Curtis and Fossum basis of a — algebra, 464
 multiplicative linear functional on a —
 algebra, 472
 structure constants of a — algebra, 465
- Heisenberg
 — group over \mathbb{F}_q , 457
 — group over $\mathbb{Z}/n\mathbb{Z}$, 437
- Hilbert Satz 90, 187, 188
- Hilbert-Schmidt inner product, 395
- homogenous space, 372
- homomorphism
 conjugation —, 280
- Hua-Vandiver-Weil theorem
 — (homogeneous case), 224
 — (non-homogeneous case), 225
- hypercube, 248
 weight of a vertex of the —, 249
- ideal
 — of a commutative ring, 167
 maximal —, 170
 principal —, 168
 principal — domain, 168
- idempotent, 390
- identity
 Bézout —, 4
 eigen—, 152
 Euler —, 31
 Fermat —, 31
 general radix —, 154
 generalized Bézout —, 5
 Hasse-Davenport —, 216
 permutational reverse radix —, 138
 reverse radix —, 149
 similarity —, 158
 twiddle free —, 157
- twiddle —, 155
- indecomposable character, 201
- induced representation, 399
 — and direct sums, 408
 — and tensor products, 406
 — from $GL(2, \mathbb{F}_q)$ to $GL(2, \mathbb{F}_{q^m})$, 533
 — of a one-dimensional representation,
 403
 character of an —, 404, 405
 matrix coefficients of an —, 404
 transitivity of —, 401
- inertia group, 421
- infinite
 — extension, 171
 — product, 76
 converging — product, 76
 diverging — product, 76
- inflation
 — of a function, 59
 — of a representation, 421, 495
- initial vertex of an oriented edge, 236
- inner product, 345
- integral domain, 167
- intertwiner, 349
- invariant
 — factors decomposition of a finite Abelian
 group, 18
 — operator, 56
 — subspace, 344
 — vector, 344
 subspace of — vectors, 344
- inverse path, 237
- inversion formula
 — for the spherical Fourier transform,
 477
 Fourier — for an Abelian group, 53
- invertible element in a commutative ring, 168
- involutive
 — algebra, 362
 — anti-automorphism of a group, 467
 — anti-automorphism of an algebra, 467
- irreducible
 — element in an integral domain, 169
 — polynomial, 169
 — representation, 344
- isomorphism
 — of directed graphs, 237
 — of graphs, 237
- isoperimetric
 — constant, 284
 Alon-Milman — inequality, 287
 Alon-Schwartz-Shapira — inequality, 320
 Dodziuk — inequality, 288
 Reingold-Vadhan-Wigderson — inequality,
 333
- isotypic component, 357
 — of $L(G)$, 384

- Jacobi sum, 217, 219
 Jacquet module of a representation, 496
 Jordan canonical form, 485
- kernel
 — of a convolution operator, 365
 — of a convolution operator on an Abelian group, 56
 — of a representation, 344
- Kloosterman sum, 210
 generalized —, 203
 orthogonality relations for generalized —s, 206
- Kronecker
 — product, 142
 — sum of linear operators, 253
 factorizations of — products, 151
 similarity of — products by stride permutations, 144
- lamplighter
 — graph, 268
 — on the complete graph, 270, 271
- Laplacian
 combinatorial —, 286
- left regular representation, 348
- Legendre symbol, 120
 — on \mathbb{F}_q , 307
- lemma
 Burnside —, 376
 converse to Schur —, 351
 Gauss —, 64
 Mackey —, 419
 Schur —, 350
 Wielandt —, 378
- length of a path, 237
- lexicographic product of graphs, 260
- little group method, 423
- loop in a graph, 235
- Mackey
 — formula for invariants, 414, 417
 — intertwining number theorem, 417
 — irreducibility criterion, 417
 — lemma, 419
 — tensor product theorem, 421
 — theory, 413
- Mackey-Wigner little group method, 421, 423
- Margulis graph, 319
- matrix
 — form of the FFT, 151
 — factorization of composite bijection permutations, 149
 adjacency —, 238
 adjugate —, 36
 block diagonal power of a —, 148
 canonical form of a —, 482
 circulant —, 58
 companion — of a monic polynomial, 191
 core —, 159, 228
 diagonal — of twiddle factors, 153
 elementary circulant permutation —, 147
 Fourier — of \mathbb{F}_q , 227
 Hankel —, 159
 permutation —, 140
 skew circulant —, 228
 unipotent —, 486
 unitary —, 345
- maximal ideal, 170
- minimal
 — central projection, 395
 — polynomial, 65, 172, 484
- modified replacement product, 282
- monic polynomial, 168
- multiple edge, 235
- multiplicative character
 — of \mathbb{F}_q , 199
 — of $\mathbb{Z}/m\mathbb{Z}$, 84
 order of a — of \mathbb{F}_q , 200
 principal — of \mathbb{F}_q , 201
- multiplicative linear functional, 472
- multiplicity
 — of a representation, 357
- multiplicity-free
 — representation, 394
 — triple, 466
 Bump-Ginzburg criterion for a — triple, 468
 spherical function associated with a — triple, 469
- multiplier operator, 444
- neighborhood of a vertex, 236
- non-backtracking path, 295
- non-oriented square, 338
- norm of a field extension, 187
- operator
 (monomial) differential —, 68
 adjacency —, 238
 adjoint —, 345
 convolution —, 365
 convolution — on $L(A)$, 56
 convolution kernel — on an Abelian group, 56
 diagonal —, 361
 invariant —, 56
 multiplier —, 444
 polar decomposition of an —, 346
 translation —, 55, 444
 unitary —, 345
- orbit of a point, 372
- order
 — of a multiplicative character of \mathbb{F}_q , 200
 — of a differential operator, 68

- order (*cont.*)
 — of a finite cyclic group, 7, 48
 — of a finite field, 176
- orientation of a graph, 236
- orthogonality relations
 — for characters, 356
 — for characters of \mathbb{Z}_n , 49
 — for characters of an Abelian group, 51
 — for generalized Kloosterman sums, 206
 — for matrix coefficients, 354
 — for spherical functions, 476, 480
 — on \mathbb{F}_q^* , 201
 — on \mathbb{F}_q , 198
- Paley graph, 308
- parabolic induction, 494
- Parseval formula
 — for \mathbb{Z}_n^2 , 312
 — for an Abelian group, 54
- partial stride permutation, 134
- partite set, 245
- path
 — composition, 237
 — in a graph, 237
 closed —, 237
 initial vertex of a —, 237
 inverse —, 237
 length of a —, 237
 non-backtracking —, 295
 terminal vertex of a —, 237
 trivial —, 237
- permutation
 — character, 375
 — matrix, 140
 — representation, 373
 — representation of S_n , 374
 composite bijection —, 136
 elementary circulant — matrix, 147
 elementary congruence —, 135
 matrix factorization of composite bijection —, 149
 partial stride —, 134
 product congruence —, 135
 shuffle —, 132
 stride —, 132
- permutational reverse radix identity, 138
- Peter-Weyl theorem, 357
- Petersen graph, 243
- Plancherel formula, 371
 — for \mathbb{Z}_n^2 , 312
 — for a finite group, 371
 — for an Abelian group, 54
 — for the spherical Fourier transform, 478
- Poisson summation formulas, 60
- polar decomposition of a linear operator, 346
- polynomial
 characteristic — of \mathcal{F} , 116
 characteristic — of \mathcal{F}^2 , 103
 characteristic — of a matrix, 484
 companion matrix of a monic —, 191
 degree of a —, 168
 irreducible —, 169
 minimal —, 65, 172, 484
 monic —, 168
 primitive —, 64
 root of a —, 65
 splitting field of a —, 174
- Pontrjagin duality, 53
- primary
 — component of an Abelian group, 22
 — decomposition of a finite Abelian group, 21, 22
- primitive
 — element of a Galois field, 176
 — graph, 242
 — polynomial, 64
 — root, 35
- principal
 — Dirichlet character, 85
 — additive character of \mathbb{F}_q , 198
 — ideal, 168
 — ideal domain, 168
 — multiplicative character of \mathbb{F}_q , 201
- product
 — congruence permutation, 135
 Cartesian — of graphs, 258
 converging infinite —, 76
 diverging infinite —, 76
 infinite —, 76
 inner —, 345
 internal tensor — of representations, 387
 Kronecker —, 142
 lexicographic — of graphs, 260
 outer tensor — of representations, 386
 replacement — of graphs, 275
 tensor — of functions, 253
 tensor — of linear operators, 253
 tensor — of subspaces, 253
 tensor — of two spaces, 384
 wreath — of graphs, 267
 zig-zag — of graphs, 277
- projection, 390
 minimal central —, 395
 orthogonal —, 390
- quadratic
 — extension, 173
 — nonresidue, 117
 — residue, 117
 Gauss law of — reciprocity, 127
 Gauss law of — reciprocity (second proof), 183

- Rader
 — Winograd algorithm, 158
 — algorithm, 159
- radix identity
 general —, 154
 permutational reverse —, 138
 reverse —, 149
- Ramanujan graph, 307
- rational canonical form, 485
- regular
 2 — segment, 252
 — graph, 236
 strongly — graph, 241
- Reingold-Vadhan-Wigderson theorem, 333
- replacement product of graphs, 275
 modified —, 282
- representation, 343
 (matrix) coefficient of a —, 351
 adjoint —, 380
 character of a —, 355
 commutant of a —, 349
 conjugate —, 380
 cuspidal —, 502
 decomposition of a —, 344
 decomposition of tensor products of —s of $GL(2, \mathbb{F}_q)$, 540
 degree of a —, 344
 dimension of a —, 344
 direct sum of —s, 344
 equivalence of —s, 344
 faithful —, 344
 induced —, 399
 induced — from $GL(2, \mathbb{F}_q)$ to $GL(2, \mathbb{F}_{q^m})$, 533
 inflation of a —, 421, 495
 irreducible —, 344
 isotypic component of a —, 357
 Jacquet module of a —, 496
 kernel of a —, 344
 left regular —, 348
 multiplicity of a —, 357
 multiplicity-free —, 394
 permutation —, 373
 permutation — of S_n , 374
 restriction of a — to a subgroup, 344
 restriction of a — to an invariant subspace, 344
 right regular —, 348
 sign —, 349
 spherical —, 474
 sub- —, 344
 unitary —, 345
- restriction
 — of a representation to a subgroup, 344
 — of a representation to an invariant subspace, 344
- reverse radix identity, 149
- Riemann zeta function, 82
 elementary asymptotics for the —, 82
 Euler product formula for the —, 82
- right regular representation, 348
- root
 — of a polynomial, 65
 primitive —, 35
- rotation map, 273
- Ruritanian map, 138
- Schur
 — lemma, 350
 — theorem on the DFT, 115
 converse to — lemma, 351
- self-adjoint
 — element in a $*$ -algebra, 362
 — projection, 390
- semidirect product
 — with an Abelian group, 424
 external —, 281
 internal —, 280
- sequence
 strictly multiplicative —, 79
- shuffle permutation, 132
- sign representation, 349
- similarity identity, 158
- simple
 — tensor, 384
 — graph, 235
- solvable group, 486
- spectral gap of a graph, 292
- spectrum of a graph, 238
- spherical
 — Fourier transform, 477
 — function associated with a — triple, 469
 — function for $GL(2, \mathbb{F}_q)$, 515
 — representation, 474
 convolution formula for the — Fourier transform, 478
 inversion formula for the — Fourier transform, 477
 orthogonality relations for — functions, 476, 480
 Plancherel formula for the — Fourier transform, 478
- splitting field, 174
 existence and uniqueness, 174
- stabilizer of a point, 372
- strictly multiplicative sequence, 79
- stride permutation, 132
 partial —, 134
- strongly regular graph, 241
- structure constants of an Hecke algebra, 465
- sub-representation, 344
- subalgebra, 361
- subfield, 171
- subgraph, 236

- symmetric Gelfand pair, 468
 symmetric group, 349
- Tao's uncertainty principle for cyclic groups, 62
- tensor
 — form of the eigenidentities, 153
 — product of functions, 253
 — product of graphs, 259
 — product of linear operators, 253
 — product of subspaces, 253
 — product of two spaces, 384
 — product and induced representations, 406
 decomposition of — products of representations of $GL(2, \mathbb{F}_q)$, 540
 internal — product of representations, 387
 outer — product of representations, 386
 simple —, 384
- terminal vertex of an oriented edge, 236
- theorem
 Alon-Boppana —, 299
 Alon-Boppana-Serre —, 298
 Alon-Boppana-Serre — (Nilli's proof), 305
 Alon-Milman —, 287
 Alon-Schwartz-Shapira —, 320
 Auslander-Feigh-Winograd —, 230
 Cauchy — for (not necessarily Abelian) groups, 21
 Cauchy — for Abelian groups, 20
 Cayley-Hamilton —, 484
 Chebotarëv —, 68
 Chevalley —, 227
 Chinese remainder —, 9, 13
 Dirichlet — $L(1, \chi) \neq 0$, 95
 Dirichlet — on primes in arithmetic progressions, 99
 Dodziuk —, 288
 Euler — $\sum_{p \text{ prime}} \frac{1}{p} = +\infty$, 97
 Euler — $\sum_{p \text{ prime}} \frac{1}{p} = +\infty$ (Erdős' proof), 98
 Fermat little —, 9
 fundamental — of arithmetic, 5
 Gauss — on cyclicity of $U(\mathbb{Z}/n\mathbb{Z})$, 35
 Gauss totient function —, 8
 Gauss-Schur — on the trace of the DFT, 116
 Green-Tao —, 100
 Hasse-Davenport —, 216
 Hilbert Satz 90, 187, 188
 Hua-Vandiver-Weil — (homogeneous case), 224
 Hua-Vandiver-Weil — (non-homogeneous case), 225
 Mackey intertwining number —, 417
 Mackey tensor product —, 421
 Mackey-Wigner little group method —, 423
- Peter-Weyl —, 357
 Reingold-Vadhan-Wigderson —, 333
 Schur — on the DFT, 115
 Tao's uncertainty principle — for cyclic groups, 159
 Warning —, 227
- trace
 — of a field extension, 187
 — of a linear operator, 353
 Gauss-Schur theorem on the — of the DFT, 116
 Hasse-Davenport identity, 216
- transitive
 — action, 372
 doubly — action, 379
- translation operator, 55, 444
- triangular graph, 242
- trivial path, 237
- twiddle
 — free identity, 157
 — identity, 155
 diagonal matrix of — factors, 153
- uncertainty principle
 — for Abelian groups, 61
 Tao's — for cyclic groups, 62
- undirected graph, 235
- unipotent matrices subgroup, 486
- unipotent matrix, 486
- unique factorization domain (UFD), 169
- unit, 55
 — in a commutative ring, 168
 — in an algebra, 362
- unital algebra, 55
- unitary
 — matrix, 345
 — operator, 345
 — representation, 345
- vector
 Bessel —, 515
 invariant —, 344
- vertex
 — of a graph, 235, 236
 —neighbor, 236
 adjacent —, 236
 degree of a —, 236
 initial — of a path, 237
 initial — of an oriented edge, 236
 terminal — of a path, 237
 terminal — of an oriented edge, 236
- Warning theorem, 227
 weight of a vertex of the hypercube, 249
 Weil-Berezin map, 447
 Whittaker model, 513
 Wielandt lemma, 378

- | | |
|---------------------------|--------------------------------|
| Winograd | Rader — algorithm, 158 |
| — method, 157 | wreath product of graphs, 267 |
| — similarity, 158 | zig-zag product of graphs, 277 |
| generalized — method, 157 | |