

SUBJECT INDEX

A

Abelian group, 282
Abraham–Minkowski debate, 18
abstract syntax, 278
accumulation point, 288
active nodes, 96, 98, *see also* free DoF
acute mesh, 83, 106, 110–119
acuteness, 112, 116–118
adherence, 288
adjoint, 315
admittance, 80
a.e. (almost everywhere), 308
affine relation, 286
affine space or subspace, 284–286
Aharonov–Bohm effect, 244, 274, 275
air mode, 253, 255, 259
algebra (of types), 276, 279, 323, 324
algebraic expression, 279
algebraic topology, 147, 148, 151, 152
altitude, 82
ampère (unit), 3, 14
Ampère rule of orientation, 5
Ampère theorem, 3, 39, 40, 50, 135, 194, 235, 239
 A_{IV} , 283
analytic ellipticity, 254
analyticity, 254, 255
and, 276
angle, 292
angular frequency, 219, 242, 251
anisotropy, 13, 14, 149
anti-linear function, 314
antisymmetric relation, 270
approximation error, 113, 117, 119, 171, 179, 288, 329, 336
approximation method, 71
arginf, 272
arithmetic expression, 281
Arrow–Hurwicz–Uzawa algorithm, 327
arrowed notation, 280
arrowed representation of fields, 301
artificial boundary, 49, 56, 200
assembly, 81, 82, 194
augmented Lagrangian, 327

augmented linear system, 173, 327
axial vector, 296, 297

B

b-oriented method, 54
Banach space, 66, 304
Banach theorem, 289
barrel, 292
barycentric coordinates, 75, 76, 286
barycentric map, 286
barycentric refinement, 99
basis functions, 71
Bath cube problem, 31, 50, 163, 195, 242, 302
Bath ladder, 303
Bean model, 266, 267
belted tree, 154, 156, 177, 235, 238
Beppo Levi space, 69, 197, 217, 226
Betti number, 146, 147, 148, 151, 160
bilateral estimate, xvii, 172, 176, 180, 189, 336
binding mechanisms, 278
Biot and Savart formula, 23, 230, 237
boldface convention, 2–3, 78, 142, 270, 284, 320
Bolzano–Weierstrass proof, 290
Boolean algebra, 264, 276, 278
bound variable, 53, 307
boundary (of a simplex or chain), 151, 153, 154
boundary (topological), 288
boundary elements, xiii, 24, 193
bounding modulo . . . (for a line or a surface), 103
bound vector, 286
box, 100, 101, 102, 111
box method, 123, *see also* finite volumes
Brillouin zones, 109

C

Cantor set, 307
cap (on a surface node), 98, 101, 102
capacitive effects, 222, 225
Cartesian product, 316
Cauchy conditions, 88

- Cauchy sequence, 304
- Cauchy–Schwarz inequality, 310
- canonical (isomorphism), 276
- cell (of dual mesh), *see* dual cell
- cgs system, 14
- chain, 150
- change of variables, 86, 90, 309
- charge (electric), 3, 4, 8, 17, 24, 25
- charge dynamics, 10, 11, 26
- charge imbalance, 26
- chart, 254, 287
- Cholesky factorization, 321, 325
- Chu formulation, 6
- circuit, 291
- circulation, 4, 40, 310
- Clifford algebra, 1
- closable operator, 126
- closed chain, 154, 234
- closed modulo . . . (for a surface or a line), 102, 163
- closed operator, 126, 316
- closed set, closure, 288
- cluster (of simplices), 75
- clustering sequences, 288, 289, 290
- co-edge, 152–156, 234–237, 335–336
- coarseness of a mesh, *see* grain
- cod 266, 320
- codomain (of a relation), 265
- coenergy, 48, 61–67, 122, 194–202
- coercivity, 249, 315
- cohomology, 133, 148
- coil, 50, 193, 194, 220, 221, 303
- collocation, 215
- commutative diagram, 144, 296
- compact operator, 251, 315
- compact set, compact part, 42, 46, 251, 288
- compactness (in existence argument), 71, 249, 290
- compartment, 6–9, 15–17, 222, 248
- compatibility of structures, 291
- complementarity, xiii, xvii, 170–180, 189, 256, 329, 338
- complementary trees, 335, 336
- complementary subspace, 285
- completion, 67, 304
- complex conjugation, 219, 249
- complexification, 219, 314
- composition (of relations), 269
- computer programming, 268, *see also* programming
- concrete syntax, 278
- condenser, 25
- condition number, conditioning, 182, 327
- conditional expression, 281
- conductivity, 10, 17, 27, 39, 248
- configuration space, 7, 8, 26, 27
- conformal transformation, 84, 86, 88
- connected set, 132
- constitutive law, 1, 6, 9, 40, 135, 175, 248, 267
- constrained linear system, 172–176, 199, 232, 233, 319, 320, 326, 330
- constraints (on DoF vectors), 149, 172–178, 181, 331, 333, 334
- constraints (on solutions), 63, 165, 169, 228
- continuous function, 289
- contractible space, 132, 299
- contraction; 312
- contravariant components, 295
- convective derivative, 25
- convergence of approximation, 79, 95, 111–119, 142
- convergence of iterative process, 182, 186, 230
- convex function, 168
- convex hull, 107, 286
- convex set, 286
- convexity and mesh-generation, 107
- convolution, 14, 216, 290
- cotangent formula, 81, 91, 110, 118, 158
- cotree, 125, 149–156, 186
- coulomb (unit), 3
- Coulomb force, 8, 11
- Coulomb gauge, 134, 274, 275, 299
- Coulomb gauge (“discrete”), 154
- covariant components, 295
- Crank–Nicolson method, 230
- critical current, 267
- critical point, 224, 227–229
- cross product, 19–20, 141, 287, 294–296
- crossing direction, 37–39, 137, 141, 287
- curl, 295
- curl–curl operator, xiv, xvii, 24, 182, 183, 239, 319
- current loop, 225, 235, 238

curvature, 69, 160, 209
 curve, 309
 curved tetrahedra, 74, 135, 200
 cut, 58, 103, 163, 176, 178, 237–239,
 329
 cycle, 151–153

D

data structure, 74, 82, 135
 de Rham's cohomology, 148
 deformation–retract, 299
 degree of freedom, 71, 78, 270
 Delaunay (Delone, Deloney), 106, *see also* Voronoi–Delaunay
 dense part, 288
 descent method, 182
 diagonals (large and small), 86, 89
 diamagnetic materials, 14
 dielectric constant, 13
 differential forms, 1, 40, 41, 55, 62, 153,
 298
 differential geometry, 41, 59, 125, 287,
 295, 296
 differential operators, 33, 41, 125, 132,
 216, 239, 281, 294–296
 differential operators (weak form of),
 128, 197
 dimension, 284
 Dirac mass, 12, 216
 direct frame, 287
 directional derivative, 34, 63, 86, 87,
 88
 Dirichlet conditions, 55, 165
 Dirichlet domains, 109
 Dirichlet problem, 55, 202, 206, 208,
 338
 Dirichlet simplex, 108, 109, *see also*
 Voronoi–Delaunay
 Dirichlet-to-Neumann map, 203–206,
 211, 215, 240
 discontinuity (at interface), 34, 36, 37,
 48, 74, 110
 discriminant, 62, 63, 168
 disjoint union, 80
 displacement current, 3, 20, 221, 247
 distance, 288
 distance in energy, 64
 distributions (in the sense of), 12, 19,
 41, 69, 104, 130, 206, 217, 260,
 275

div-conformal field, 97, 329, 338
 divergence, 296
 div–grad operator, xiv, xvii, 24, 239
 dom, domain, 265, 266
 domain (dual meaning of), 27, 33
 domain (as open connected set), 3, 291
 dominated convergence, 307
 dot product, 292
 double integrals, 214
 double-multiplier approach, 328
 doubling (of DoFs), 135, 178, 237
 drift velocity, 10
 dual cell, 100, 108, 139, 188
 dual graph, 155, 336
 dual mesh, 99, 100, 101, 108, 139
 duality (of convex functions), 168
 dualization of constraints, 59, 173
 dummy variable, 264, *see also* bound
 variable
 dynamics, 5, 7–9, 11, 20, 195

E

E_3 , 294
 Earnshaw "theorem", 105
 eddy currents, xv, 220
 edge element, xv, 140
 effective conditioning, 182–183
 effective group action, 282
 Eiffel tower, 300
 eigenmode, 251
 eigenvalue, 182, 183, 251, 252, 259, 261,
 315, 326
 electret, 13, 15
 electric potential, 22, 40
 electromagnet, 193
 electromagnetic energy, 16
 electromagnetic field (as a mathematical
 structure vs as a physical entity),
 1, 5, 20, 32, 66, 274, 297
 electromotive force, xv, 40, 243, 244
 electron, 8, 9, 10, 13, 274, 275
 electrostatics, 22, 23, 67, 105, 203, 211
 eligible functions, 47, 52–54, 63, 65, 70,
 164, 288
 ellipsoid, 293
 energy flux, 18
 equation, 53
 equivalence, 271
 equivalence class, 68, 69, 88, 197,
 271–274, 285, 287, 296, 308

equivalent permeability, 21
 error estimate, 112, 116–119, 132, 338
 error estimator (for mesh refinement), 337
 error in constitutive law, 168, 170, 175, 188, 198, 329, 330, 336
 essential boundary conditions, 55, 165
 Euclidean structure, 292, 293
 Euler equation, 64, 71, 168, 169, 198, 199, 205, 207, 227, 229, 312
 Euler–Poincaré formula, 96, 99, 148, 184, 330, 334
 Euratom casing, 303
 exact sequence, 146, 299
 expression, 279
 extension (of a relation), 268
 extension by continuity, 130, 305
 external orientation, 58
 extrusion, 36

F

$f(x)$ (ambiguity of), 280
 face element, 140
 factorization, *see* LDL^t , Cholesky, Gauss
 faithful group action, 282
false, 276
 family, 269
 fan map, 88
 farad (unit), 6
 Faraday's law, 3, 4, 5, 13, 36, 243, 274, 297, 298, 302
 Fast Fourier Transform, 231
 Felix brick, 303
 ferrite, 21
 ferromagnetic materials, 14, 23
 Feynman disk paradox, 20
 finer than, 271
 finite differences method, 85
 finite volume methods, 102, 106, 111
 finite volume of support, 197
 fixed point condition, 9
 flatness, 116–118, 183, 260
 fluid dynamics, 25
 flux, 4, 40, 310
 flux loss, 96, 98, 101, 120, 121
for all quantifier, 278
 force, 8, 9, 19, 24, 25, 44, 60, 80, 194, 195, 297
 Foucault currents, 220

Fourier component, 302
 Fourier series, 304, 315
 Fourier transform, 12, 14, 248
 fractal, 67, 300
 frame, 287
 Fredholm alternative, 249, 315
 free degrees of freedom, 80
 free variable, 53, 264, 278–281
 free vector, 286
 Friedrichs inequality, 157, *see also* Poincaré inequality
 Fubini theorem, 132, 160, 216, 290, 308
 functional, 62, 281
 functional graph, 126, 129, 266, 316
 functional point of view, 2–3, 52, 62, 65, 125, 164, 195
 functional programming, 268
 functional space, 64

G

Galerkin method, xvi, 71–73
 Gâteaux derivative, 63
 gauge (w.r.t. a convex set), 293
 gauge invariance, 18
 gauging, 88, 154, 169, 174, 186, 274, 275, 299, 322, 333
 gauss (unit), 14
 Gauss quadrature formulas, 78
 Gauss factorization, 319
 Gauss quadrature formulas, 78
 Gauss–Seidel algorithm, 270
 generalized sequence, 273
 generalized solution, 70, 125–126
 generators, 10, 15
 gradient, 295
 grain (of a mesh), 112–117, 142, 260, 337
 graph (of a relation), 265
 graph closing and hole plugging, 129
 Green operator, 281
 grot (for the $SCALAR \rightarrow VECTOR$ surface operator), 189
 group, group action, 282

H

h-oriented method, 54
 Hadamard, (well posed in the sense of), 9, *see also* well-posed problem
 harmonic functions or fields, 35, 47, 84, 86, 88, 105, 144, 208, 209, 228, 242, 260

harmonic time evolution, 21, 63, 219,
 222, 223, 231, 247
 hat function, 77
 heat equation, 17
 Heaviside notation for vectors, 3
 Helmholtz decomposition, 166, 196,
 197
 henry (unit), 6
 Hermitian elements, 78
 Hermitian matrix, 230, 235
 Hermitian scalar product, 219, 232,
 249, 314
 high permeability, 31, 39, 89, 92, 152
 Hilbert problems, 35
 Hilbert space, 66, 69, 125, 128, 310,
 311
 Hilbert space and dual, 207, 313
 Hilbert transform, 248
 Hilbertian geometry as extension of
 Euclidean geometry, 312, 315
 Hilbertian methods in BVP, 206
 hole (as topological feature), 145, 147,
 148, 154, 165, 225
 holes (as charge carriers), 10
 hollow tetrahedron, 147
 holomorphy, 84, 88
 homeomorphism, 87, 147, 148, 243, 289
 homogeneity, 283, 293
 homogeneity of physical space, 285
 homogeneous space, 283
 homology, 58, 102, 148–156
 homology class, 164
 homology cycle, 155, 156
 homotopy, 291, 299
 hypercircle, xvii, 169, 171, 189
 hysteresis, 14, 21, 195, 267

I

i vs j (for $\sqrt{-1}$), 3
 icosahedron, 335
 image (of a set), 268
 impedance, 224, 248
 incidence matrix, incidence number, 75,
 135–139, 143, 154, 158, 176,
 201, 232–233
 incidence matrices (for dual mesh), 139
 incidence number, 136, 137, 138, 143,
 176
 independence (in linear space), 284
 induction heating, 17, 21, 220, 221, 267

inertia, 28, 194
 infimum, supremum, 272
 infinite dimensional space, 284
 infinite elements, 201
 inf-sup condition, 161
 inner orientation, 137, 138, 287, 295
 integration by parts, 16, 25, 42, 45, 65,
 129, 187, 202, 206, 211, 224, 253,
 309, 310, 315
 integral method, 202
 integration-by-parts formulas, 130
 interaction (between compartments), 1,
 6, 9, 13–17, 275
 interface condition, 44, *see also*
 discontinuity
 interference, 274, 275
 interior (of a set), 288
 interpolation error, 113–117, 119
 inverse (of a relation), 266
 inverse image, 268
 inverse problem, 23
 involution, 302
 isometry, 289
 isomorphism, 276
 isosceles tetrahedron, 85
 isotropy, 283, 293
 isotropy group, 283, 293, *see also* little
 group

J

Jacobi identity, 118
 Jacobian, 27, 90
 Jamet criterion, 117
 Joule heating, Joule losses, 15, 17, 165
 jump, 34–39, 96–98, 102, 181, 187, 210,
 238, 241

K

ker, 320
 kernel, 286
 kinematics, 5, 7
 Kirchhoff laws, xv
 knot, 234, 239–244

L

L^2 , 308
 L^6 , 69, 197
 L^∞ , 93
 Lagrange multiplier, 173–176, 233,
 326, 328

Lagrangian, 173, 327
 Lagrangian elements, 78
lambda quantifier, 280
 lambda-calculus, 280
 Laplace equation, 55, 189
 Laplace transform, 21
 law of tangents, 35, 97
 Lax–Milgram lemma, 198, 199, 224, 313, 315
 LDL^t factorization, 319, 322, 326
 Lebesgue integral, 69, 290, 305–310
 Lebesgue measure, 308
 left action (of a group), 282
 lifting, 105, 151, 194, 204–206
 limit, 288
 linear group GL_{IV}, 293
 linear map, 284
 linear order, 271
 linear space, 283
 linearity in constitutive laws, 14, 21, 164, 195, 248
 link, 50, 58, 114, 163, 176, 329
 little group, 283, 293, 300, 301
 load (in a microwave oven), 247, 248, 253, 259
 load (of an electromagnet), 193, 194
 localization (of non-quantal objects), 275
 localization (of energy), 17
 localization heuristics, 331
 logic, 277
 loop (as closed path), 291
 loop (as program construct), 82, 325
 loop (as topological feature), 145, 147, 153, 154, 165, 225, 235, 237, 299
 loop (in a graph), 336
 Lorentz force, 8–10, 25
 Lorenz gauge, 274, 275, 299
 low-frequency approximation, 221, 222

M

m^{*}-cap, 102
m^{*}-cells vs Voronoi cells, 108
m^{*}-line, *m*^{*}-path, 150, 179
m^{*}-surface, 101, 104, 150
 M-matrices, 84
m-path, 150
m-solenoidal, 330

m-weak properties, 72, 73, 95, 154, 179, 261, 329
m-weak solenoidality, 72
 machine-epsilon, 325
 magnet, 14, 15, 23, 25, 56
 magnetic charge, 5
 magnetic core, 48, 49, 102, 193, 225, 231, 240, 300, 309, 310
 magnetic current, 5
 magnetic energy, 48, 61, 164, 194, 198, 199, 253
 magnetic potential, 40, 51, 165, 240
 magnetic susceptibility, 14
 magnetic wall, 61
 magnetization, 2, 13, 14, 23
 magnetomotive force, xv, 40, 50, 61, 64, 86, 122, 179, 188, 234, 236, 242, 243
 manifold, 137, 138, 204, 287
 mapping, 266
 mass conservation, 8, 24
 mass matrix, 148, 149, 176, 201
 MATLAB, 324
 maximal element, 271
 maximal subgroup, 293
 maximum principle, 95, 105, 106
 maximum principle (discrete), 105, 106, 110, 119
 maxmin angle property, 109, *see also* Zlamal condition
 Maxwell equations, 1, 2, 20, 39, 125, 134, 135, 253, 255, 260, 297
 Maxwell house, 134, 145, 167
 Maxwell model, 11, 14, 21, 22
 Maxwell tensor, 19
 Maxwell–Whitney house, 145
 measurable function, 308
 mediator set, 122
 memory (in constitutive laws), 14
 mesh (of a cube), 90
 mesh generators, 74
 mesh refinement, 97, 100, 114, 182, 260, 271, 288, 336, 337
 mesh-wise, 76
 meteorology and VD meshes, 110
 metric, 292
 metric space, 288
 microwave oven, 21, 247, 255
 minimal element, 271

minimizing sequence, 65–67, 71, 182, 273, 311
 mirror symmetry, 254, 300, *see also* symmetry
 mixed elements, 161
 mixed formulation, 176
 mixed system, 174
 MKSA system, 6
 Möbius band, 37, 38, 287
 model, xiv, xvii, 1, 2, 7, 11, 14, 20–24, 27, 32, 48, 51, 66, 75, 164, 195, 219, 220, 247, 319
 model (discrete vs continuous), 96, 103, 134
 modelling, xiii, 1, 32, 39, 47, 66, 67, 71, 103, 122, 145, 239, 244, 293, 300, 319, 326
 modelling (two-dimensional), 24, 67, 69, 220, 259, 304
 modulus, 292
 mollifier, 132, 290
 momenergy, 18
 moments (method of), xiii, xv
 momentum, 8, 9, 18–20
 monotone matrices, 84
 monster-barring (in the sense of Lakatos), 67
 moving conductors, 10
 multiple integrals, 308
 multivaluedness of the magnetic potential, 240
 myth, 10, 11, 13, 26, 28

N

n-tuple, 264
 natural boundary conditions, 56
 negligible set, 4, 48, 69, 308, 309
 network methods, 106
 Neumann conditions, 55, 338
 Newton laws, 20
 Newtonian potential, 216, 280
 Newton–Raphson method, 195
 Nicolson, 230, *see also* Crank–Nicolson
 nodal function, 76
 nonnegative number, 271
 nonnegative definite matrix, 320
 nonpositive coefficients, 109
 normal derivative (defined as a distribution), 130
 normed space, 291

not, 276
 notation (differential geometric), 2, 45
 notation for
 convolution, 290
 dual mesh, 100
 duality, 206
 fields, 8, 17
 functions, using arrow, 12, 158, 217, 279–281
 functional spaces, 41
 groups, 282
 integrals, 4, 307
 jumps, 36
 Lagrange elements, 77
 nodal functions, 139
 normal derivative, 55, 210
 program objects, 323
 relations, 271
 scalar product, 249
 sets of simplices, 176
 Sobolev spaces, 129, 205
 test functions, 52
 vectors, using boldface, 3
 vectors of DoF, using boldface, 3, 71, 284
 weak operators, 128
 numbering (of nodes), 270

O

object-oriented programming, xvi, 276, 322
 obtuse angle problem, 84, 110–112, 116–118, 120
 octahedron, 91, 92
 off-diagonal terms, 83, 84, 106, 109, 122, 185, 259, 330, 335
 Ohm’s law, 9–11, 14, 21, 26, 27, 134, 219
 open ball, open set, 288
 open space problems, 193
 operation, 275
 operator, 281
 operator d , 41, 148, 152
or, 276
 order, ordering, 271
 orientation, 20, 58, 135, 136, 287, *see also* inner orientation
 orthocomplement, 312
 orthogonal grid, 91
 Ostrogradskii–Gauss formula, 3, 17

outer orientation, 287
overloading symbols, 189, 276, 323

P

pairs vs couples, 264
parabolic vs elliptic equations, 239
paradox, 20, 216, 241, 244, 275
parallel affine subspaces, 53, 72, 286
parallelism (in computing), 335
paramagnetic materials, 14
parity, 302
parsing, 280, 281
partial function, 266
partial order, 271
particle-in-cell method, 9
partition of unity, 77, 83, 331, 332, 337
patch, 291
patch (around a surface node), 98
path, 291
paving (as synonym for mesh), 76
paving (space), 85, 87, 91, 92
permeability, 21, 31, 50, 61, 85, 92, 105, 152, 223
permittivity, 13, 248
permutation, 282
permuting limit and integration, 307
piecewise smooth, 34,
pivot, 325, 326
placement, 75, 200, 201
plasma, 7
Poincaré gauge, 299
Poincaré inequality, 134, 157, 197
Poincaré lemma, 132, 133, 165, 298, 299
Poincaré–Steklov operator, 203
Poincaré–Wirtinger inequality, 157,
 see also Friedrichs
point vs vector, 286
pointwise bilateral estimates, 172, 189
Poisson problem, 22, 55
polar coordinates, 89, 210
polar form, 62
polar vector, 297
polarization, 2, 11, 12, 13, 248
polynomial expression, 76
positive definiteness, 83, 292, 320
power density, 8, 15, 17
Poynting vector, 16, 18
pre-Hilbertian space, 64, 66, 292, 308, 311
pre-image, 268

precedence, 266, 280
precondition, 325
primal graph, 336
primal mesh, 100
principal directions, 293
principal submatrix, 81, 122, 182
program (as a function), 268
programming, 77, 82, 235, 270, 322
programming language, 268, 276, 278, 323
projection (on a subspace), 64
projection (of a set), 265
property, 265
pull-back, 77, 90, 200
punctured torus, 241, 243
push-forward, 200, 301
Pythagoras theorem, 64, 189, 311

Q

quantifiers $\forall$, λ , $\exists$, *see* end of index
quadratic form, 62
quadratic optimization problem, 170, 172, 173
quaternion, 2

R

railgun, 20
rank (of a matrix), 153, 154, 174
reference frame, 10, 15, 27, 136, 300
reference mesh, 200
reflexive relation, 270
regular domain, 3
regular group action, 283
regular mesh, 85
regularization by convolution, 131, 290
relation, 265
relative homology, 58, 152
relative loop, 165
relative tree, 153–55
reluctance, 32, 51, 58, 65, 85, 103, 120, 122, 164–176, 189, 329, 336
representative element, 273
representative section, 273, 285
restriction, 268
retardation effects, 241
Riemann integral, 306–308
Riemannian geometry, 158
Riesz vector, 172, 313, 314, 317
right action (of a group), 282

Ritz, 71–73, 77, *see also* Galerkin
 rot-conformal field, 329
 rot-rot, 319, *see also* curl-curl operator

S

sagittal graph, 272
 scalar (electric) potential, 274, 280
 scalar (magnetic) potential, xvi, 31, 32, 48, 53, 95, 177, 214, 236, 336
 scalar product, 292
 section (of a set), 265
 Seifert surface, 234, 237–241, 243
 semi-positive definite matrix, 319, 326
 sesqui-linear form, 315
 shape functions vs basic functions, 77, 161
 siemens (unit), 10
 simplex, 75, 77
 simplicial complex, 135
 simplicial torus, 146
 simply connected space, 132, 236, 291
 singular solution, 69
 singular values, 252
 singularity (of a function), 39, 67, 84, 157, 159, 217
 singularity (of a matrix), 182, 186
 skew frame, 287
 skew-symmetric matrix, 320
 smooth over, 34, 57, 133, 203, 206, 298

 SO_2 , 283, 293, 304
 Sobolev space, 129, 197, 203, 250, 309
 solenoid, 243, 244, 275
 span, 83, 284
 spanning tree, 153–156, 176, 186, 233–237, 335, 336
 sparsity, 82, 215
 sphere property (of VD meshes), 108, 120, 122
 spike effect, 67
 spin, 13
 spurious modes, 161, 260, 261
 stabilizer, 283, *see also* little group
 star-shaped domain, 298
 static condensation, 104, 215
 stationarity, 22, 23, 25, 242
 stationarity (of a functional), 63, 224, 227
 Steklov, 203, *see also* Poincaré-Steklov operator

stereographic projection, 335
 Stieltjes matrix, 83, 84, 109, 111, 122
 stiffness matrix, 80, 87
 Stokes and “Helmholtz” decomposition, 196
 Stokes theorem, 4, 41, 57, 58, 152, 188, 242, 251, 275, 295–298, 301
 support, 41, 290
 sup, supremum, 271
 surjective, 266
 surface differential operators, 187
 syllogism, 278
 Sylvester law of inertia, 326
 symmetric relation, 270
 symmetry of
 barrels, 292, 293
 bilinear form, 314
 a domain, 50, 163–164, 255, 282, 300–304
 a field, 301
 material properties, 301
 Maxwell equations, xvii, 5, 51, 134, 164, 336
 an operator, 215
 a relation, 278
 symmetry argument, 86, 90
 symmetry cell, 300
 symmetry group, 163, 300

T

$\tan \delta$, 22
 tangent space, 286
 tangent vector, 309
 tangential part, 36, 38, 130, 141, 187, 188, 227, 255, 256
 Taylor expansion, 85, 114
 TEAM workshop, xiv, 31, 220, 302–304
 tensor, 13, 14, 19, 87, 149, 282
 tensor product, 19
 tesla (unit), 14
 tessellation (as synonym for mesh), 74, 106, 135
 tessellation by dual cells, 100, 108
 test function, 42
there exists quantifier, 278
 thermal agitation, 10
 Thiessen polygons, 109
 time domain methods, 21, 231, 259
 Tonti diagram, 167

topological inclusion vs set inclusion, 204
 total function, 266
 total order, 271
 trace, 37, 130, 131, 187, 203–214, 226, 228, 251, 309
 transformer, 51
 transitive relation, 270
 translation, 284
 transmission condition, 33, 35, 39, 40, 43, 44
 tree, 152, 153
 trial functions, 71
 triangulation, 76, 109
 Trifou, xv, 213, 225, 226, 229, 240
true, 276
 type (of an object), 17, 40, 62, 68, 70, 189, 213, 266, 323

U

u-adapted Whitney elements, 200
 unary operation, 275, 277
 uniformly continuous function, 289
 unimodular group, 293
 uniqueness (in cavity problem), 250
 uniqueness and existence, 55, 72
 unordered n-tuple, 264, 269

V

variational crime, 79, 113, 169, 215
 variational equation, 312
 variational formulation, xiii, *see also* weak formulation
 variational framework, 195
 variational method, xvi, 54, 195, 312
 variationally correct approximation, 104, 122, 179

vector, 284

vector potential, 23, 40, 274
 as responsible for AB effect, 275
 gauged, 299
 in Maxwell's notation, 2
 vector potential approach, 54, 170, 172, 174, 177–180, 185, 186
 vectorized program
 vector space, 283
 vectorial nodal elements, 161, 177, 180, 181, 184

vertex vs node, 74
 virtual work principle, 44
 Vlasov–Maxwell model, 7, 8, 24
 V_{iv} , 283
 volt (unit)
 Voronoi cell, 107–111, 123
 Voronoi–Delaunay mesh, 95, 106–110

W

Watson–Bowyer algorithm, 110
 waveguide, 256
 weak convergence, 315
 weak differential operators, 128, 197
 weak divergence, 127
 weak form vs variational form, 63
 weak formulation, 44, 46, 53, 54, 56, 59, 63, 126, 127, 131, 206, 224, 229, 256
 weak gradient, 127
 weak instability, 230
 weak solenoidality, 42, 44, 96, 127, 261
 weak vs strong formulation, 250
 weber (unit), 5, 14
 Weierstrass theorem, 289
 well-posed problem, 9, 164, 198, 252, 259
 Weyl lemma, 35, 66, 206, 254
 Whitney complex, 142, 145–148, 175, 229
 Whitney elements, xvi, 125, 135, 139–152, 161, 186, 189, 232, 261
 Whitney forms, xv, 125, 140
 Whitney sequence, 135
 Wigner–Seitz cells, 109

Z

Zlamal condition, 115, 116

d, 41, 148, 152

#, 270

$\Rightarrow$, 277

$\forall$, 278

$\rightarrow$, 279

λ , 280

$\exists$, 278

$\cong$, 280

ae , 308

$*$, 25