

Index

Figures are in **bold**. Individual singularity or bifurcation types are listed under ‘singularity type’ or ‘bifurcation type’ respectively

- \mathcal{A} - (left-right) equivalence, 148
- \mathcal{C} -equivalence, 130
- Δ_F (discriminant), 92
- \mathcal{E}_n (germs of smooth functions), 35
- \mathcal{E}_n^+ (ring of even germs), 120
- f^{-1} (of a module), 146
- $\mathrm{GL}_n(R)$, 376
- Id_r ($r \times r$ identity matrix), 338
- I_f (ideal of a map), 131
- $\mathcal{I}(V)$ (polynomial ideal of a variety), 231
- I_V (ideal of a variety), 233
- Jf (Jacobian ideal), 51
- Jf (Jacobian module), 144
- \mathcal{K} - (contact) equivalence, 129
- \mathcal{K}_1 -equivalence, 162
- \mathcal{K}_V -equivalence, 247
- \mathcal{L} - (left) equivalence, 145
- \mathfrak{m}_n (maximal ideal in \mathcal{E}_n), 35
- tf (tangent map), 64, 375
- wf , 146, 375
- \mathcal{R} - (right) equivalence, 49
- \mathcal{R}_1 -equivalence, 71
- \mathcal{R}^+ -equivalence, 50
- $\mathcal{R}(V)$, 241
- Σ_G (singular set of a bifurcation problem), 126
- Σ_f (singular set of a map), 127
- θ_n (germs of vector fields), 63, 144
- $\theta(f)$ (vector fields along f), 139
- θ_n^\pm (even/odd vector fields), 120, 122
- $\mathcal{VF}(V)$ (polynomial v. fds tgt to V), 231
- $\theta_{V,0}$, 248
- θ_V (germs of v. fds tgt to V), 233
- \triangleleft (ideal), 369
- \triangleleft (submodule), 374
- \rightarrowtail , 20, 315, 335
- acnode, 112
- adapted basis, 317
- adjacencies of simple singularities, 178–182
- adjugate matrix, 377
- algebraic closure, 229
- algebraic multiplicity, 134
- Arnold, V.I., 87, 88, 103
- astroid, **184**, 184
- base space, 92, 126, 175
- bifurcation, 2, 13
 - equivalence, 258
 - problem, 10, 13, 125–128, 219, 257–290
 - classification, 285–287
 - regular, 126
 - set, 2, 25, 92
 - full, 30
- bifurcation set, *see* discriminant
- bifurcation theory, xi, 219, 355
- bifurcation types
 - beaks, 266
 - fold, 2
 - hysteresis, 15, 222, 225, 311
 - isola, 225
 - lips, 266
 - pitchfork, 128, 221, 263, 269
 - deformations, **223**
 - degenerate, 301
 - quartic fold, 273
 - quintic fold, 276
 - saddle-node, 2, **3**, 3, 222, 224
 - transcritical, 222, 224
 - winged cusp, 264
- big-oh notation $O(k)$, 39
- bilinear form, 319
- bimodal singularity, 103, 312, 413

- binary cubic forms, 85, 173
- binary quadratic forms
 - pencils of, 168
- biplanar point, 191, 194
- bitangent plane, 191
- Boardman symbol, 170, 174
- butterfly, 101, 276, 278, 301
- cardioid, 193
- catastrophe set, 24, 25, 92, 126, 192
- catastrophe theory, xi
- Cayley cross-cap, 180, 211, **212, 230, 230, 347**
- centre of curvature, 9, 192
- chain rule, 324, 327
- Clairaut equation, 187
- classification
 - \mathcal{A} -equivalence, 210–214, 295
 - bifurcation problems, 285–287
 - corank-1 critical points, 83
 - corank-1 singularities, 167
 - corank-2 critical points, 84–86
 - corank-2 singularities, 169
 - elementary catastrophes, 86
 - paths, 259–283
 - simple singularities, 88
- cobasis, 43, 142, 322
- codimension, 52, 170
 - alternative, 153
 - contact equivalence, 151
 - finite, 43, 152
 - left equivalence, 147
 - left-right equivalence, 149
 - of submanifold, 345
 - of subspace, 321
 - plane curve singularity, 111
- coherent variety, 243, 245
- cokernel, 355
- complete vector field, 362, 365
- complexification, 77
- cone
 - vector fields tangent to, 236
- constant rank theorem, 350, 354
- constant tangent space, 159, 160, 164, 273, 276
- \mathcal{K}_V -equivalence, 249
- contact, 189
- contact equivalence, 129
- contour, 4, 15
- coordinates
 - about a point, 337
 - change of, 337
 - linearly adapted, *see* linearly adapted coordinates
- corank
 - of a map, 166
 - of a bifurcation, 284
 - of a critical point, 56, 81
 - of a map, 216
- corank 1 singularity, 167
- corank 2 singularity, 167
- core, 166, 181, 220, 353, 355
- critical point, 20, 51
 - degenerate, 20, 55
 - nondegenerate, 19, 20, 23, 52–55, 69, 78, 92, 137, 138, 393
- critical values, 309
- crunode, 112
- cubic form, 321
 - binary, 84
 - classification, 85
 - elliptic, 85
 - hyperbolic, 85
 - parabolic, 85
 - symbolic, 85
- cusp, 114
 - catastrophe, 26, **27, 29, 91, 98**
 - curve, 346
 - family, 30, 101
 - map, 137, 197, 206
 - of Gauss map, 191
 - point, 6, 10, 387
 - singularity, 112
- cuspidal edge, 107
- deformation, *see* unfolding
- degenerate critical point, 20
- derivation, 231, 371
- derlog, 231
- diffeomorphic

- subsets, 338
- diffeomorphic ideals, 132
- diffeomorphism, 336
- differential, 20, 322
 - higher, 326
 - notation, 326
- dimension, 345
- direct sum, 321
- discriminant, 2, 6, 13, 14, 25, 92
 - of a bifurcation problem, 126
 - of a family of curves, 111
 - of a map, 128
 - of pencil, 173
- distance squared function, 8
- distance-squared function, 192
- Dynkin diagram, xii
- elementary catastrophes, 86
- elimination, 381
- embedding, 340
- envelope
 - of a family of lines, 184, 185
- equivalence
 - contact (\mathcal{K}), 129
 - \mathcal{K}_V , 247
 - left (\mathcal{L}), 145
 - left-right (\mathcal{A}), 129, 148, 211, 293
 - of bifurcation problems, 258
 - of unfoldings, 96, 176
 - right, (\mathcal{R}), 49
- Euler vector field, 152, 234, 380
- even function, 119–121
- evolute, 9, **10**, **15**, 15, 103, 193, 387
- exceptional singularity, 87
- Faà di Bruno’s formula, 327
- family
 - of functions, 23, 25, 92
 - of maps, 125
- field, 368
- finite codimension
 - germ, 52
 - ideal, 43
- finite determinacy, 153
 - for \mathcal{K} , 164
- for \mathcal{R} , 67, 75
- for \mathcal{R}_1 , 71
- finite singularity type, 165, 171–173, 180, 291, 294, 297
- flat function, **323**, 323, 333
 - ideal of, 376, 384
- flow from a vector field, 330, 362
- flying saucer, 272
- fold, 30, 206
 - family, 10, 23
- fold bifurcation, *see* bifurcation, saddle-node
- fold catastrophe, 23
- folded handkerchief, 151, 165, 356
- full bifurcation set, 310
- function v. map, 19
- generating function, 389
- generators (of an ideal), 369
- genotype, *see* core
- geometric criterion, xv, 45, 77, 148, 171, 215, 254, 382
- geometric subgroup, 153
- germ
 - equivalence, 34, 46
 - representative, 34
- germ equivalent sets, 34
- graph unfolding, 216, 292
- Hadamard’s lemma, 36, 46, 58, 166
- Hessian
 - matrix, 20, 52, 325
 - of a cubic, 90
- homeomorphism, 336
- homogeneous polynomial, 60, 379
- homotopy equation, 73, 75
- homotopy method, 68, 72, 147, 156, 164
- hypersurface, 114, 234
- ideal, 369
 - finitely generated, 369
 - Jacobian, 51, 384
 - maximal, 35, 370
 - of a map, 131
 - of a variety, 231, 233

- imperfect bifurcations, 12, 219
- implicit function theorem, 342
- index
 - of a critical point, 21, 55, 106, 387
 - of a quadratic form, 321
- induced unfolding, 95, 175
- initial speeds, 97, 176
- integral curve, 365
- invariant theory, 201, 242
- inverse function theorem, 339
 - proof of, 72
- Jacobian ideal, *see* ideal, Jacobian jet, 39, 67, 84, 329, 364
- Koszul vector fields, 235
- Lagrange multipliers, 137, 138, 357, 402
- left-right equivalence
 - with singular source, 296
- Leibniz rule, 372
- lemniscate, 400
- level sets, 4
- Lie algebra, xii, 245
- linearly adapted coordinates, 339, 352, 357, 414
- lists of bifurcations, 285–287
- little-oh notation, 326
- local algebra, 131, 138, 171
- local group property, 361, 363
- local immersion theorem, 340
- local submersion theorem, 342
- Lyapunov–Schmidt reduction, 354, 355, 358
- Macaulay2, 238
 - code, 246
- Martinet’s theorems, 207, 209, 216
- Martinet, J., 175, 176, 205, 207, 209
- Mather, J.N., xii, 129, 132, 195, 205, 207
- matrix over a ring, 376
- Maxwell set, 310
- Milnor number, 78, 152
- miniversal unfolding, 98
- minors of a matrix, 318
- module, 141, 373
 - finitely generated, 374
 - Jacobian, 144
- modulus, 103, 207, 265, 288, 312, 413
- Morse index, *see* index
- Morse Lemma, 22, 55, 69
- multigerm, 215
- multiplicity, 134, 137, 171, 242, 402
- Nakayama’s lemma, 41, 53, 377, 378
- Newton diagram, 40, 42
 - for submodules, 143, 179
- nice dimensions, xv, 207
- Noetherian ring/module, 42, 45, 201, 231, 242, 375
- nondegenerate critical point, 20, 52
- normal form
 - critical points, 88
 - matrix, 317
 - versal unfoldings, 101
- normal space, 292
- nullity (of a quadratic form), 321
- Nullstellensatz, 45, 77, 171, 382, 384
- odd function, 119
- order (of a map germ), 39, 213
- organizing centre, 220
- parabolic point (of a surface), 190
- parameter, 1–13, 219
- path
 - regular, 292
- path equivalence, 258
- pencils of binary quadratic forms, 168
- pinch-point, 211, 212, 212
- pitchfork bifurcation, *see under*
 - bifurcation type
- polarization (of quadratic form), 320, 333
- Porteous, I.R., 88, 188
- potential function, 2
- preparation theorem, 97, 119, 196–205, 409
- probes, 89, 191
- proper ideal, 369

- quadratic form, 320
 - index, 321
 - nullity, 321
 - pencil, 168
 - signature, 321
- ramphoid cusp, 213, **214**
- rank
 - of a map, 335
 - of a matrix, 316, 348, 358
- recognition problem, 88
- regular
 - family, 126
 - parametrization, 352
 - point, 352
 - unfolding, *see* unfolding, regular
 - value theorem, 348
- remainder function
 - from splitting lemma, 56, 60
- restriction of a function, 46
- resultant, 381
- ridge point, 192
- right equivalence, 49
- ring, 367
 - homomorphism, 370
 - local, 35, 370
 - quotient, 370
- saddle-node bifurcation, *see under* bifurcation type
- semicontinuous, 349
- semicubical parabola, 27, 147, 231, 248, 261, 324
- signature (of a quadratic form), 321
- simple singularity, 87, 101, 211, 284
 - adjacencies of, 103
- singular point, 20
 - of a curve, 324
- singular set, 24
 - of a bifurcation problem, 126
 - of a map, 128
 - of an unfolding, 92
- singularity
 - of a map, 352
 - plane curve, **110**, 109–114, 212
- singularity theory, xi
- singularity types
 - $I_{a,b}$, $II_{a,b}$, IV_a , 170
 - A_k , 23, 83, 87, 167, 179
 - D_k , 87, 107
 - E_6 , E_7 , E_8 , 88
 - folded handkerchief, 151, 165, 170
 - $T_{p,q,r}$, 88
- smooth, 322
 - curve, 6, 109
 - family, 2, 25, 63, 91, 121, 126
 - function, 347, 358
- source, 315
- span, 43
- spinode, 114
- splitting lemma, 55, 61, 81, 84, 87, 93, 105, 284
- stability, 12, 61
- stable
 - map, 206
 - map germ, 206, 209
- state variable, 2, 25, 92, 126, 219, 259
- straightening map, 208, **345**, 345, 348, 397
- submanifold, 92, 99, 345
- submersion, 341
- super- and sub-critical pitchfork bifurcations, 14, 385
- suspension, 180, 181, 344
- swallowtail, 30, 101, **102**, **104**, 106, 114, 180, 275, 397
 - generalized, 179
- symmetric bifurcations, 299
- symmetric matrices, 358
- symmetry, 13, 119
- tacnode, 114
- tangent map, 63, 333
- tangent space
 - contact, 149
 - contact, extended, 150
 - K_V , 248
 - left, 146
 - left-right, 148
 - logarithmic, 254, 255

- right, 66, 145
- right, extended, 140, 145
- to a submanifold, 348
- target, 315
- Taylor series, 326
- theorem
 - finite determinacy for \mathcal{K} , 164
 - finite determinacy for \mathcal{R} , 68
 - finite determinacy for \mathcal{K}_V , 250, 253
 - implicit function, 342
 - extended, 343
 - inverse function, 339
 - proof of, 72
 - local immersion, 340
 - local submersion, 342
 - preparation, 196
 - regular value, 348
 - versality for \mathcal{K} , 176
 - versality for \mathcal{R} , 97
 - versality for \mathcal{K}_V , 253
- Thom, R., xi, 13, 86, 91, 97, 101, 207
- Thom–Levine principle, 65–79, 156–162, 249, 312, 393
- Tjurina number, 152
- transversality, 173, 227, 254, 350
- trilinear map, 321
- trioid singularity, 245, 255
- trivial family, 64, 160
- umbilic, 30, 84, 101, 192
 - elliptic, **104**, 108
 - hyperbolic, **105**, 108
 - parabolic, 86, 89
- unfolding, 91, 92, 175
 - regular, 176, 181, 207
- unimodal
 - path, 265, 288, 289
 - singularity, 103
- unit (in a ring), 368
- variational problems, 13, 19, 49, 103, 309–312
- variety
 - algebraic, 229, 231–233, 240, 247, 254, 371
 - algebraic v. semialgebraic, 230
 - analytic, 371
 - semialgebraic, 229
- vector field, 330
 - along a map, 64, 146, 331
 - tangent to a variety, 231
 - tangent to discriminant, 237
 - vertical, 154
- versal unfolding
 - \mathcal{K}_V -equivalence, 253
 - contact equivalence, 176
 - proofs of, 198
 - right equivalence, 97–104, 198
- weighted homogeneous, 234, 379
- Whitney umbrella, 211, **230**, 230, 239
- Whitney, H., xii, 119, 197, 207
- Zeeman, E.C., xi, xiii
 - catastrophe machine, 5, 27, 104
- zero-set, 112, 126, 130, 136, 175, 257, 299, 406