

Index

- AD-OO framework, 342, 415, 599
Add-on modules, 598
Additive property, 561
Adjacency matrix, 521, 538
Adjoint equations, 425
Agglomeration, 541
 a priori flow indicator, 551
 feasible directions, 541
 flow indicator, 547
 global flow indicator, 551
 greedy algorithms, 548
 local flow indicator, 551
 merging blocks, 546
 permissible directions, 541
 refining blocks, 547
 volume indicator, 546
Annular space, 395
Annulus, 396
Anonymous function, 205
Anticline, 25, 27
API gravity, 372
Aqueous phase, 233
Aquifer, 256
Areal sweep, 308
Assembly, 435
Automatic differentiation, 204, 623–629
- Basis functions, 178, 180
Bi-stream function, 130
Biconnected components, 543
Black-oil equations
 gas component, 392
Black-oil models, 246
 equation of state, 372
 formation-volume factor, 371
 oil component, 390
 primary unknowns, 389
 primary variables, 392
 shrinkage factor, 371
- solution gas–oil ratio, 371
vaporized oil–gas ratio, 371
water component, 389
- Bottom-hole pressure, 122
- Boundary conditions
 data structure, 146
 Dirichlet, 120, 147
 hydrostatic, 161
 linear pressure, 161
 Neumann, 120, 147
 no flow, 120, 146
- Bubble point, 362
Bubble-point curve, 362
Bubble-point pressure, 375
Buckley–Leverett, 259, 281, 284, 298, 417
Bundle of tubes, 236
- Capillary fringe, 320, 330
Capillary pressure, 235
 Brooks–Corey, 239
 hysteresis, 237
 Leverett J, 238
 van Genuchten, 239
- Carbonate rock, 24
Carman–Kozeny, 37
Cartesian grid, 57
Cell-mode script, 603
CFL condition, 275, 278
Christmas tree, 365
Circumcenter, 63
Circumcircle, 63
Class object, 401
Clastic rock, 23
CO₂ storage, 301, 311
Coarse grid, 519
Cocurrent flow, 251
Compatible discretization, 188
Component conservation, 245
Components, 233

- Compositional flow, 245
Compositional simulation, 338
Compressibility
 constant, 117
 fluid, 117
 gas (isothermal), 373
 oil, 376
 oil (isothermal), 378
 rock, 36
 slightly, 118
 total, 117, 252
 water, 379
Compressible flow, 117
Computational overhead, 418
Computational steering, 419
Condensate, 360
Connate water saturation, 233
Connected components, 521
Conservative method, 275
Consistent, 174
Constitutive equations, 116
Constrained pressure residual (CPR), 444
Contacted volumes, 482
Control step, 403, 416, 438, 471
Convergence
 nonlinear, 403, 438
 rate, 326
Convergent, 174
Coordinate system, 91
Corner-point grid, 45, 48, 73
Countercurrent flow, 251
Critical point, 361
Critical temperature, 361
Crossflow, 395
Curvilinear grid, 58
Cylinder coordinates, 122, 124
- Darcy
 flow experiment, 113
 Henry, 36, 113
 unit, 36, 40
 velocity, 115
Darcy's law, 14, 36, 115
Darcy–Buckingham equation, 257
Data set
 CaseB4, 79, 536, 550
 Johansen, 44, 529
 Norne, 79, 323
 SAIGUP, 46, 97, 171, 514, 532
 SPE 1, 455
 SPE 10, 41, 307, 501, 551, 585
 SPE 10, Tarbert, 495
 SPE 3, 355, 409
 SPE 9, 355, 383, 460
 SPE 1, 350, 355, 383, 399, 409
Data structure
 boundary conditions, 146
- coarse grid, 519, 525
fluid properties, 144
grid, 88
reservoir states, 145
source terms, 145
wells, 147
Dead oil, 247, 342, 380
Delaunay, 63
Dew point, 362
Dew-point curve, 362
Disconnected blocks, 521
Discrete operators, 135, 203
 average faces to cells, 218
 averaging, 207
 divergence, 136, 206
 divergence (wells), 397
 gradient, 136, 206
 gradient (wells), 397
 harmonic average, 215
 upwind, 141, 222
Displacement
 favorable, 262, 308
 unfavorable, 262, 308
Dissolution matrix, 452
DistMesh, 69
Downscaling, 560
Drainage, 237
Drainage region, 480
Dry gas, 382, 383
Dulmage–Mendelsohn, 169, 309, 522
- ECLIPSE input, 46, 97, 339
 ACTNUM, 48, 80
 COMPDAT, 402
 COORD, 48, 75
 DENSITY, 383
 EDIT, 340
 GRAVITY, 383
 GRID, 340
 INCLUDE, 341
 METRIC, 49
 MULTX, 48
 MULTZ, 50
 NTG, 48
 PERMX, 48
 PORO, 48
 PROPS, 340, 350, 379
 PVCDO, 380
 PVCO, 381
 PVDG, 382, 383
 PVDO, 380
 PVTG, 382
 PVTO, 381, 383
 PVTW, 382
 PVZG, 382
 REGIONS, 340
 ROCK, 383

- ECLIPSE input (cont.)
 - ROCKTAB, 383
 - RUNSPEC, 340, 380
 - SATNUM, 48, 52
 - SCHEDULE, 340, 402
 - SGOF, 351
 - SOLUTION, 340, 400
 - SUMMARY, 340
 - SWOF, 351
 - TABDIMS, 380
 - TSTEP, 403
 - TUNING, 403
 - WCONINJE, 402
 - WCONPROD, 402
 - WELSPECS, 402
 - ZCORN, 48, 75
- ECLIPSE output, 350
- Energy equation, 220
- Energy minimization, 179
- Enhanced oil recovery, 5
- Enthalpy, 221
- Entropy condition, 261
 - Lax, 261
 - Oleinik, 261
- Entry pressure, 236, 320
- Equation of state
 - compressibility, 373
 - cubic, 119
 - gas deviation factor, 373
 - Peng–Robinson, 119
 - Redlich–Kwong, 119
 - Redlich–Kwong–Soave, 119
- Error
 - capillary dominated flow, 330
 - grid-orientation, 176, 187, 330
 - mass balance, 439, 464
 - normalized residual, 439, 464
 - splitting, 293, 326
 - temporal, 326
 - truncation, 174, 276, 285
- Exercises
 - advanced grids, 108
 - agglomeration, 553
 - arithmetic vs. harmonic, 215
 - automatic differentiation, 629
 - averaging, 569
 - boundary conditions, 164
 - buoyant migration, 312
 - consistent schemes, 187
 - discretization operators, 142
 - efficiency of prototype code, 228
 - flow diagnostics optimization, 504
 - flow diagnostics, SAIGUP, 516
 - flow-based upscaling, 574
 - fluid object, 292
 - global upscaling, 580
 - grid coarsening, 539
 - grid structure, 96
- heterogeneity measures, 489
- heterogeneous q5-spot, 310
- homogeneous q5-spot, 306
- hyperbolic schemes, 282
- incompressible solvers, 325
- intro to MRST, 608
- modules in MRST, 619
- multisegment wells, 459
- non-Newtonian fluids, 220
- numerical errors, 334
- quarter five-spot, 159
- rock properties, 52
- sector model, 453
- single-phase with wells, 173
- single-phase, compressible, 212
- single-phase, incompressible, 169
- SPE 9 benchmark, 469
- structured grids, 61
- three-phase intro, 359
- unstructured grids, 71
- unstructured stencils, 169
- upscaling sector model, 594
- upstream methods, 286
- volume averaging, 563
- wells, incompressible, 173
- Expansion factor, 371
- Explicit flux representation, 184
- Face mobility, 215
- Facies, 238
- Facility model, 433
- Fanning friction factor, 399
- Fault trap, 27
- Faults, 26, 39, 49
- Fickian diffusion, 245
- Fictitious domain, 60
- Finite-volume method, 132
- Five-spot, 126
- Flow capacity, 483
- Flow diagnostics, 477
- Flow equation, 250
- Flow resistance, 458
- Fluid object, 16, 290
 - black-oil, 355
 - ECLIPSE input, 350
 - relative permeability, 144
 - saturation, 144
 - single phase, 144
- Fluvial, 28, 42
- Formation-volume factor, 123, 124, 247
 - gas, 371, 373
 - oil, 371, 375
 - total, 376
 - water, 379
- Fractional-flow formulation
 - global pressure, 254
 - phase potential, 255
 - phase pressure, 250–254

- Fractional-flow function, 250
 Fracture, 25
 Fully implicit, 244
 Function spaces
 H_0^{div} , 178
 $H^{\frac{1}{2}}$, 183
 L^2 , 178
- Gas compressibility factor, 373
 Gas liberation
 differential, 365
 flash, 365
 Gas lift, 396
 Gas reservoir, 365
 condensate, 366
 dew-point, 366
 dry, 366
 retrograde condensate, 366
 rich, 366
 wet, 366
 Gaseous phase, 233
 Generating points, 63
 Geochemistry, 338
 Geological model, 10, **30**
 Geostatistics, 40
 Gibbs' phase rule, 360
 Global numbering, 447
 Global pressure, 254
 Global-pressure formulation, 254
 Godunov scheme, 278
 Gravel pack, 396
 Gravity
 API, 372
 specific, 372
 Gravity column, 14, 267, 301
 Gravity override, 315
 Grid
 Cartesian, 57
 coarse, 519
 composite, 101
 conformal, 103
 corner-point, 73, 97
 curvilinear, 58
 data structure, 88
 Delaunay, 63
 disconnected blocks, 521
 DistMesh, 69
 fictitious domain, 60, 523
 geometry, 93
 multiblock, 104
 partition, 519
 PEBI (2.5D), 85
 PEBI (2D), 67
 PEBI (3D), 104
 rectilinear, 57
 stair stepped, 79
 stratigraphic, 72
 tessellation, 63, 68
 Triangle, 69
 Voronoi, 66, 104
 Grid-orientation errors, 176, 330
 Heat conduction, 221
 Hele–Shaw cell, 307
 Heterogeneity, 483
 Heterogeneity measure
 dynamic, 483
 F–Φ diagram, 484
 Lorenz coefficient, 486
 static, 483
 sweep efficiency, 487
 High-pressure cell, 362
 Homogenization, 560
 Hybrid, mixed, 182
 Hydraulic conductivity, 2, 114, 257
 Hydraulic head, 113
 Hydrocarbon recovery
 primary production, 3
 secondary production, 4
 tertiary production, 5
 Hysteresis, 237
 Ideal gas, 118
 Imbibition, 237
 Immiscible, 232
 Immobile oil, 237
 Implicit discretization, 203
 Incompressible flow, 117
 Indefinite system, 184
 Indirection map, 89
 Inflow control device, 396
 Inflow–performance relation, 122, 394
 Influence region, 479, 497
 Injectivity, 310
 index, 122
 Inner product
 continuous, 178
 discrete, 180
 local, 185
 mixed hybrid, 183
 Input deck, 48
 Irreducible saturation, 233
 Jacobian matrix, 204, 295, 296, 309
 Johansen data set, **44**
 JOLTS, 598, 602, 603
 K-orthogonal, 176, 333
 Klinkenberg effect, 239
 Laplace operator, 117
 Lax–Friedrichs, 275
 Lax–Wendroff, 276
 Leverett J-function, 238
 Limestone, 22

- Line-search method, 296
 Linear solver
 AGMG, 153, 445, 463
 algebraic multigrid, 445
 condition number, 347
 CPR, 444, 463
 direct, MATLAB default, 152
 GMRES, 442
 ILU preconditioner, 443
 iterative methods, 341
 Krylov subspace method, 442
 `mldivide`, 152, 303, 309
 multigrid, 153
 nested factorization, 447
 orthomin, 447
 preconditioner, 341
 Thomas algorithm, 303
 triangular system, 156
 tridiagonal system, 303
 Linearization, 203
 Linearized problem, 434
 Linearly degenerate wave, 261
 Lithography, 72
 Live oil, 247, 367, 381, 383
 Local numbering, 447
 Local-flux mimetic, 196
 Logical indexing, 99
 Lorenz coefficient, 486, 501
 M-matrix, 197
 Marine rock, 23
 Mass conservation, 116
 Mass fraction, 233
 Mass-balance error, 439
 MATLAB
 `accumarray`, 621
 `arrayfun`, 346
 `bsxfun`, 621
 `cellfun`, 305, 353
 `classdef`, 401, 423
 handle classes, 437
 indirection maps, 89
 logical indexing, 99
 run-length encoding, 89
 Mesh generator, 69
 Method of characteristics, 259
 Metis, 538
 Mimetic finite differences, 188
 consistency, 189
 Mimetic inner product, 189–196
 general family, 190
 parametric family, 191
 quasi RT0, 195
 quasi two-point, 193
 simple (default), 195
 two-point, 193
 Min-max angle criterion, 63
 Ministep, 438
 Miscible displacement, 246
 Mixed finite elements, 177
 Mixed formulation, 178
 Mixed hybrid, 182
 Mixture velocity, 397
 Model
 black-oil, 430
 facility, 433
 physical, 422
 reservoir, 426
 wells (multisegment), 433
 wells (Peaceman), 433
 Model object, 414
 Modules, 598, 610
 `ad-blackoil`, 430, 615
 `ad-core`, 416, 600
 `ad-eor`, 616
 `ad-fi`, 616
 `ad-mechanics`, 616
 `ad-props`, 351, 615
 adjoint, 615
 `agglom`, 541, 613
 `blackoil-sequential`, 420, 615
 book, 10, 157, 619
 `co2lab`, 617
 `coarsegrid`, 614
 compositional, 616
 `deckformat`, 48, 350, 405, 615
 design rules, 612
 `dfm`, 618
 `diagnostics`, 153, 480, 616
 dual-porosity, 618
 `enkf`, 619
 `fvbiot`, 618
 geochemistry, 618
 `hfm`, 618
 `incomp`, 16, 149, 614
 `libgeometry`, 614
 `linear solver`, 446
 `linearsolvers`, 619
 `matlab_bg1`, 619
 `mimetic`, 186, 599, 614
 `mpfa`, 196, 599, 615
 `mrst-cap`, 619
 `mrst-gui`, 53, 619
 `msmfe`, 617
 `msrsb`, 617
 `octave`, 607, 619
 `opm_processing`, 614
 optimization, 616
 `remso`, 619
 `solvent`, 616
 `spe10`, 42, 619
 `steady-state`, 616
 `streamlines`, 159, 619
 `triangle`, 69, 614

- upr, 104, 614
upscaling, 572, 616
vem, 615
vermech, 618
wellpaths, 619
Monotone, 197
Mudrock, 22
Multicomponent flow, 245
Multilateral well, 396
Multiplier, 39, 50, 323
Multipoint flux approximation, 196
Multisegment well, 339, 395, 455
Nested factorization, 447
Net-to-gross, **38**, 50
Newton update, 204, 296
Newton–Raphson, 203, 295
Non-neighboring connection, 74
Non-Newton fluid, 215
Norne data set, 79
Numerical context, 415
Octave, 607
Oil reservoir, 365
 black-oil, 367
 bubble-point, 367
 solution gas, 367
 volatile, 367
Oil-water contact, 237
Oleic phase, 233
Operator splitting, 292

Partition
 agglomeration, 541
 confined blocks, 543
 disconnected, 521, 542
 flow indicator, 544
 graph algorithms, 538
 grid faces, 527
 hierarchical, 554
 load balanced, 519
 METIS, 538
 near well refinement, 536
 segmentation, 542
 volume indicator, 544
Partition of unity, 479
Partition vector, 519
Pathline, 129
Peaceman, **126**, 169
PEBI grid, 67, 85
Periodic medium, 560
Permeability, 2, **36**
 absolute, 239
 anisotropic, 37
 Carman–Kozeny relation, 38
 effective, 239
 isotropic, 37
Johansen, 45
modeling in MRST, 39
relative, 240
SAIGUP, 51
SPE 10, 44
Perpendicular bisector, 66
Phase (dis)appearance, 393
Phase diagram, 360
 binary substances, 362
 bubble-point reservoir, 368
 crichtonbar, 364
 crichtontherm, 364
 critical point, 363
 gas reservoirs, 366
 single-component system, 360
Phase mobility, 244
Physical model, 416
Pillar grid, 73
Poisson's equation, 117
Polymer flooding, 216
Pore volumes injected (PVI), 326
Porosity, **35**
 Carman–Kozeny relation, 38
 Johansen, 45
 SAIGUP, 51
 SPE 10, 43
Potential ordering, 309
Preconditioner, 442
Pressure decline, 4
Pressure equation
 global pressure, 254
 phase-potential formulation, 256
 two-phase compressible, 253
 two-phase incompressible, 250
Primary production, 3
 combination drive, 4
 gas cap drive, 4
 gravity drive, 4
 solution gas drive, 4
 water drive, 4
Production-logging tool, 482
Productivity index, 122, 394
Properties
 extrapolation, 408
 interpolation, 408
Pseudo components, 233
 gas, 246
 oil, 246
Quarter five-spot, 126, 157
 heterogeneous, 307, 327
 homogeneous, 303, 326
 rotated, 330
Radial flow, 122, 167
Rankine–Hugoniot, 260
Rarefaction wave, 261

- Raviart–Thomas, 180
 Rectilinear grid, 57
 Relative permeability, 240
 Brooks–Corey, 241
 Corey, 241
 default in ECLIPSE 100, 349
 in *ad-props*, 353
 SPE 1,3,9, 356
 Stone I, 242
 three-phase, 348
 two-phase, 241, 242
 van Genuchten, 242
 Repeated five-spot, 126
 Representative elementary volume, **31**, 232, 560
 Reservoir simulation, 6
 Residence time, 478
 Residence-time distribution, 479, 490
 Residual equations, 294
 Residual saturation, 233
 Result handler, 419
 Retrograde condensate gas, 387
 Retrograde gas condensate, 366, 377
 Reynolds number, 399
 Rheology
 Newtonian fluid, 215
 non-Newtonian fluid, 215
 shear thickening, 216
 shear thinning, 216
 Rich gas, 382, 387
 Richards' equation, 256
 Riemann fan, 262
 Riemann problem, 262
 Rock types, 51
 Root folder, 601
 Rosebrock, 629
 Rotated gravity, 311
 R_s -factor, 371, 372, 375, 381, 383, 385
 Run-length encoding, 89
 R_v -factor, 371, 372, 375
 S-shape, 251
 SAIGUP data set, **46**, 97
 Sand screen, 396
 Sandstone, 22
 Saturated, 368, 375
 Saturation, 232
 connate water, 233
 effective, 238, 241
 irreducible, 233
 residual, 233
 Saturation equation
 phase-potential formulation, 256
 two-phase compressible, 254
 two-phase incompressible, 250
 Schedule, 340, 402, 418, 457, 462
 Schur-complement, 184
 Secondary production, 4
 waterflooding, 4
 Sedimentary environment, 23
 Sedimentary rocks, 21
 Self-sharpening wave, 261
 Sequential fully implicit, 420
 Sequential solution, 292
 Shale, 22, 239
 Shallow marine, **24**, 28, 42
 Shear factor, 217
 Shock wave, 261
 Shrinkage factor, 247, 371
 Simulation model, 7, 401
 Skin factor, 125, 394
 Solution gas-oil ratio, 247, 371, 375, 381
 Source terms, 145
 Sparsity pattern, 167
 SPE 10 data set, 41
 Specific gas, 373
 Specific gravity
 gas, 373
 liquid, 372
 Stability analysis, 284
 Stable, 174
 State object, 145
 flux, 145
 pressure, 145
 saturation, 145
 well solution, 145
 Stock-tank, 364
 Storage capacity, 483
 Storage coefficient, 257
 Stratigraphic grid, 72
 Stratigraphic trap, 27
 Streakline, 129
 Streamline coordinates, 304
 Streamlines, **128**, 158
 Structural model, 31, 47, 49
 Subset extraction, 99
 Summary file, 405
 Supercritical state, 361
 Surface area, specific, 38
 Surface tension, 234
 Sweep efficiency, 487
 Sweep region, 480, 496
 Syncline, 25
 Tarbert, 42
 Tessellation, 63
 Test function, 178
 Thermal expansion
 adiabatic, 224
 free, 223
 Joule–Thomson, 224
 reversible, 224
 Thermal: single-phase, 220
 Thin-tube experiment, 235
 Time loop, 210
 Time-of-flight, 129, 153
 backward, 478

- forward, 478
- per influence region, 482
- Time-step
 - chopping, 297, 393
 - control, 297, 415, 463
 - selection, 416, 439
- Topological sort, 309
- Tortuosity, 38
- Tracer, 129, 156
- Tracer distribution, 130
- Transmissibility, 16, 133
- Transport equation, 250
- Trial function, 180
- Triple point, 360
- Truncation error, 174, 285
- Two-point scheme, 16
 - conditionally consistent, 175
 - derivation, 132–133
 - half-transmissibility, 133
 - implementation, 150
 - linear system, 133
 - nonlinear TPFA, 200
 - transmissibility, 133
- Unconditionally stable, 283
- Unconventional reservoirs, 239
- Undersaturated, 368, 375
- Unsaturated flow, 256
- Upper Ness, 42
- Upscaling, 559
 - arithmetic average, 564
 - fallback strategy, 585
 - flow diagnostics, 581
 - flow-based, 570
 - generic conditions, 579
 - geometric average, 564
 - global, 579
 - harmonic average, 564
 - harmonic-arithmetic, 567
 - ill-posed problem, 564
 - laboratory boundary conditions, 570
 - local-global, 579
 - oversampling, 578
 - parallel layers, 566
 - periodic, 571
 - permeability definition, 564
 - perpendicular layers, 565
 - positive transmissibilities, 577
 - power average, 564
 - specific conditions, 579
 - transmissibility, 575
 - volume average, 561
 - well indices, 584
 - Wiener bound, 564
- Upstream mobility weighting, 279
- Upwind scheme, 278
- Vadose zone, 256
- Vanishing viscosity, 273
- Vaporization curve, 362
- Vaporized oil–gas ratio, 247, 371, 375
- Variable elimination, 436
- Variable switching, 393
- Velocity reconstruction, 218
- Vertical equilibrium, 450
- Viscosity
 - gas, 374
 - oil, 378
 - water, 379
- Viscous fingering, 307
- Volatile oil, 360, 367, 377
- Volumetric partition, 479
- Voronoi, 66, 104
- Water coning, 313
- Water content, 257
- Waterflooding, 4
- Well allocation factor, 482, 581
- Well head, 365
- Well model
 - crossflow, 395
 - flow rate, 208
 - frictional pressure drop, 398, 457
 - hydrostatic pressure, 208
 - inflow-performance relation, 122
 - injectivity index, 122
 - mobility calculation, 395
 - multisegment, 397
 - Peaceman, 126–128, 169
 - productivity index, 122
 - scaling, 443
 - simple valve, 398, 457
 - skin, 125
 - surface rate, 209
 - well control, 209, 428, 451
- Well pair, 480
- Well placement, 502
- Well-pair region, 480
- Wells, 121, 338
 - control, 338, 402, 423, 462
 - control switching, 453, 464
 - data structure, 147
 - flow rate, 147
 - horizontal, 455
 - multisegment, 339, 455
 - simple, 457
- Wet gas, 382
- Wettability, 234
 - contact angle, 234
 - non-wetting, 234
 - oil wet, 235
 - water wet, 235
 - wetting, 234
- Workbook, 603