

# Index

- adaptive grid, 275  
adiabatic displacement, 49, 52  
adiabatic lapse rate, 52  
adjoint, 251  
Agulhas current, 3  
algebraic eigenvalue problem, 8  
amplification factor, 251  
angle of elevation, 29  
angle of obliquity, 59, 67, 75, 144  
angle of repose, 269, 271  
angular velocity, 175  
aquifer, 241  
Aristotle, 3  
artillery gunners, 281  
aspect ratio, 78  
  
baroclinic instability, 206, 211, 215  
  ageostrophic, 219  
basis functions, 277  
Bessel equation (modified), 181  
Bickley jet, 78, 128, 280, 282  
bioconvection, 235  
bores, 117  
Boston, 107  
boundary condition, 12, 157, 178  
  asymptotic, 71, 72, 285  
  fictitious, 72  
  fixed, 157  
  free slip, 142  
  frictionless, 142, 218  
  impermeable, 68, 71, 209, 218  
  insulating, 157  
  no-flow, 142  
  solid, 142  
boundary value problem, 8  
Boussinesq approximation, 15  
Brunt-Väisälä frequency, 26  
buoyancy, 15, 26  
buoyancy flux, 131, 133  
  
buoyancy frequency, 26, 49  
buoyancy production, 133  
buoyancy variance, 132  
  
Canary Islands, 108  
centered difference, 11  
centrifugal force, 175  
centrifugal instability, 177, 182, 183, 316  
compressible fluid, 48  
continuity equation, 13  
continuum hypothesis, 17  
convection, 24, 190, 235, 244, 316  
  Benard, 162  
  biological, 235  
  diffusive, 228, 230  
  salt fingering, 228  
  sheared, 133, 162, 303  
convection cells, 47  
convective instability, 316  
convergence, 78  
conveyor belt, 3  
coordinate  
  axial, 174  
  azimuthal, 174  
  Cartesian, 13, 196  
  radial, 174  
Coriolis acceleration, 14, 195  
Coriolis force, 196  
Couette flow (plane), 139  
critical level, 88, 103, 129  
critical level theorem, 89  
critical state, 24, 45, 49, 67, 165, 238, 244  
cycle of instability, 6  
cyclic instability, 171  
  
deformation radius, 213  
density ratio, 226  
derivative matrix, 9, 12, 13, 68, 218, 273  
differential eigenvalue problem, 8, 13, 281

- diffusive convection, 228, 269  
 diffusive layering, 233  
 diffusivity  
     molecular, 16  
     turbulent, 16, 265  
 Dirac delta function, 36, 118  
 discretization, 68  
 dispersion relation, 31, 68, 98, 116, 209, 211  
     Eady wave, 209, 211  
     internal gravity wave, 31, 116  
     vorticity wave, 98  
 double diffusion, 224  
 e-folding time, 33  
 Eady mode of baroclinic instability, 213  
 eddy  
     mesoscale, 4, 196, 206, 214, 215  
     submesoscale, 4, 215  
 eigenfunction, 59, 66, 293  
 eigenvalue, 8, 13, 69, 71, 156, 179, 218, 249, 275,  
     279, 281, 288, 293, 298, 302  
 eigenvalue problem  
     algebraic, 8, 60, 249, 278  
     differential, 8, 60, 288  
     generalized, 68  
 eigenvector, 13, 69, 156, 179, 189, 218, 248, 249, 298,  
     302  
 Ekman spiral, 134  
 energy flux, 82  
 enstrophy, 257, 258  
 equation  
     Orr-Sommerfeld, 140, 286  
     pressure, 112, 155  
     Rayleigh, 60, 274, 286  
     Taylor-Goldstein, 115, 193, 286  
 equations of motion, 13  
     cylindrical coordinates, 174  
 equatorial undercurrent, 270  
 equilibrium, 25, 54, 111, 139, 155, 242  
     cyclonic, 175, 243  
     frictional, 138, 243  
     geostrophic, 196, 243  
     hydrostatic, 25, 196, 243  
     quasi-, 139, 155  
     strict, 139, 155  
     thermal wind, 196  
 exponential growth, 29  
 fastest-growing mode, 24, 31  
 finite differences, 10, 273, 275  
 finite differences, higher order, 273  
 Fjørtoft's theorem, 87, 104, 105, 180  
 flux  
     buoyancy, 131, 133  
     kinetic energy, 82, 133, 150  
     momentum, 83  
 force  
     centrifugal, 190
- Coriolis, 14, 196  
 friction, 14  
 gravitational, 14  
 pressure gradient, 14  
 Fourier's theorem, 30, 31  
 Fourier-Galerkin method, 277  
 frazil, 223  
 frequency  
     angular, 29  
     cyclic, 29  
 front, 195  
     polar, 195  
 frontal zone, 195  
 frozen flow approximation, 139, 140, 164  
 gain, 251  
 Galerkin methods, 277  
 geostrophic equilibrium, 196  
 Gibraltar, 169  
 glacial ice, 55  
 gravity currents, 117  
 gravity wave, 31, 122, 125, 126  
 Green's function, 188  
 Greenland, 55  
 groundwater, 240  
 growth rate, 67  
 Gulf Stream, 3, 196  
 Holmboe instability, 123, 165  
 Howard's semicircle theorem, 89, 129  
 humidity, 222  
 hydraulic jumps, 117  
 hydrostatic balance, 112, 154  
 hydrostatic equilibrium, 25, 196  
 incompressible fluid, 15  
 Indian Ocean, 71  
 inertial instability, 316  
 inflection point, 85, 86, 103, 194  
 inflection point theorem, 85  
 influence function, 120, 188  
 influence matrix, 189  
 initial growth, 253  
 initial value problem, 8, 247  
 inner product, 257  
 instability, 33  
     axisymmetric, 174, 180, 186  
     baroclinic, 206, 211, 215, 244, 269  
     barotropic, 174, 177  
     broadband, 32, 41  
     centrifugal, 177, 182, 183, 186, 190, 202, 316  
     conditional, 222  
     convective, 24, 190, 202, 244, 316  
     cyclic, 171, 269  
     diffusive convection, 230, 269  
     Holmboe, 123, 132, 165  
     inertial, 202, 316  
     Kelvin-Helmholtz, 117, 119, 165

- mixed layer, 215
- oscillatory, 33, 66, 168, 230, 314
- Phillips layering, 265
- primary, 262
- Rayleigh-Taylor, 36, 117, 120, 316
- salt finger, 228, 268
- secondary, 262, 264
- secondary convective, 262
- secondary Kelvin-Helmholtz, 264
- shear, 53, 170, 269
- stationary, 33, 66, 314
- subharmonic pairing, 262
- symmetric, 200, 215, 244
- Taylor-Caulfield, 126
- Tollmien-Schlichting, 147
- interface, 36
- internal gravity wave, 31, 122, 125, 126, 167
- intrinsic phase speed, 98
- isolated wave, 97
  - Eady, 212
  - gravity, 126
  - vorticity, 97
- isomorphism, 24, 42, 74
- isopycnals, 215
- jet
  - Bickley, 78
  - triangular, 97
- jump condition, 38, 62, 121, 185
- Kelvin-Helmholtz clouds, 165
- Kelvin-Helmholtz instability, 117, 119, 165
- kinetic energy, 80, 198
  - flux, 81, 133, 150
  - perturbation, 80
- Kronecker delta, 68
- Lake Kivu, 235
- lapse rate
  - adiabatic, 52, 222
  - moist adiabatic, 222
- linear extrapolation, 283
- linearization, 26, 176
- matching function, 282
- material derivative, 13
- Matlab, 8, 70, 73, 287, 288, 293, 303
- mechanism, 6, 81, 91, 108, 125, 183, 190, 200, 202, 233, 243
- Meddy, 269
- Mediterranean Outflow, 169
- Mediterranean Sea, 269
- mesoscale eddies, 3, 196, 206, 214, 215
- microorganisms, 235
- Miles-Howard theorem, 127, 133
- mixed layer, 215
  - mode
    - fastest-growing, 66
    - stationary, 66
    - mode family, 171
    - mode, sinuous, 79
    - mode, varicose, 80
    - momentum flux, 83
    - money, diffusion of, 266
  - Mount Everest, 284
- Nares Strait, 108
- neutrally stable waves, 65
- norm, 258
- normal matrix, 251
- normal mode, 24, 29, 59, 247
- numerical solution methods, 68, 143, 156, 215, 273, 281
- Nyquist wavelength, 279
- oblique mode, 75, 113, 144, 158
- obliquity, 59, 67, 75, 113, 144, 151, 158
- observational data, 169
- Orr-Sommerfeld equation, 140
- oscillatory instability, 33, 66, 168, 230, 314
- outer space, 316
- Pacific Ocean, 270
- parcel method, 49
- pendulum, 20
- perpetual salt fountain, 224
- perturbation, 56, 111
  - perturbation equations, 24, 53, 140, 153, 176, 226, 237
  - perturbation kinetic energy, 80, 150
  - perturbation theory, 17, 26
- phase locking, 97, 98, 125, 126
- phase speed, 59, 67
- phase tilt, 90
- plane wave, 29
- Poiseuille flow (plane), 138, 147, 244
- polar front, 195
- polarization relations, 60, 61
- positive feedback, 99, 210, 266
- potential density, 52
- potential vorticity, 206
- Prandtl number, 43
- Prandtl ratio, 209, 214
- pressure, 155
  - pressure equation, 112, 155
  - pressure gradient, 15
  - production
    - buoyancy, 133
    - shear, 82, 150
- Python, 8
- quasigeostrophic flow, 206
- quasigeostrophic potential vorticity, 206
  - linearized, 208
- Rankine vortex, 183

- Rayleigh discriminant, 180, 244  
 Rayleigh number, 44, 47, 224, 244  
 Rayleigh's equation, 60, 62, 274  
     numerical solution, 68  
 Rayleigh's inflection point theorem, 86, 104, 180  
 Rayleigh-Benard convection, 41  
 Rayleigh-Taylor instability, 120, 316  
 re-dimensionalization, 75  
 resonance, 91, 95, 97, 99, 187  
     Eady wave, 211, 221  
     vorticity wave, 95, 97  
 resonance approximation, 126  
 Reynolds number, 140, 145, 244, 263  
 Richardson number, 127, 133, 205, 215, 219, 244,  
     264, 270, 271  
     bulk, 110  
     geostrophic, 205  
     gradient, 110  
     minimum, 110  
 Rossby wave, 96  
 rules of thumb, 7, 48, 67, 77, 244  
  
 salt fingering, 228, 268  
 sandpile analogy, 269  
 scale height, 215  
 scaling, 24  
     buoyancy, 162  
     diffusion, 42  
     shear, 73, 145, 161, 219  
 self-organized criticality, 269  
 semicircle theorem, 129, 133  
 sequestration, CO<sub>2</sub>, 239  
 shear flow  
     boundary layer, 53  
     jet, 53  
     parallel, 53, 107, 137  
     wake, 53  
 shear layer, 53, 67, 256  
     hyperbolic tangent, 77, 110, 145, 244, 279  
     piecewise-linear, 61, 93, 255, 256  
     viscous, 146  
 shear production, 81, 82, 90, 150  
 shear production theorem, 85, 88  
 sheared convection, 133, 162  
 shooting method, 281  
     multiple, 285  
     parallel, 281  
 sine series, 277  
 singular value decomposition, 253, 259  
 singularity, 88  
 sinuous mode, 79  
 smoke rings, 194  
 solitary wave, 117, 167  
 solution algorithm, 43, 75, 144, 146  
 spatial growth, 134  
 spatial instability, 134  
 spring-mass system, 20  
 Squire transformation, 75, 114, 144, 158, 159  
  
 stability boundary, 88, 116, 164, 211  
 stationary instability, 33, 66, 314  
 stratification, 49  
 stratified shear layer, 110, 128  
 streamfunction, 175  
 supercooled water, 223  
 superposition, 30  
 swirling flows, 192  
 symmetric instability, 200, 215  
  
 Taylor-Caulfield instability, 126  
 Taylor-Goldstein equation, 115, 133  
 theorem  
     critical level, 89  
     Fjørtoft, 87, 104, 105, 180  
     Howard's semicircle, 89, 129  
     inflection point, 86, 104, 180  
     Miles-Howard, 127, 164, 165  
     shear production, 85, 88  
 thermal wind balance, 196, 215  
 thermocline, 215  
 thermohaline interleaving, 266  
 thermohaline staircase, 241  
 thermohaline stratification, 225  
 tilted tank experiment, 108  
 trade winds, 271  
 transient growth, 248  
 troposphere, 215  
 turbulence, 6, 16, 137, 147, 262  
  
 ultraviolet catastrophe, 120  
  
 varicose mode, 80  
 veering flow, 134, 160  
 velocity kink, 62  
 vertical buoyancy flux, 131  
 virtual boundary, 71  
 viscosity, 14, 15, 137  
     eddy, 16  
     kinematic, 16  
     molecular, 15, 16  
     turbulent, 16, 137, 265  
 vortex, 174, 244  
     columnar, 174  
     cylindrical, 174  
     Rankine, 183  
 vortex stretching, 199, 206  
 vortex tilting, 199, 206  
 vorticity, 93, 175, 199, 218  
     axial, 193  
     planetary, 199  
     potential, 206  
 vorticity interface, 94  
 vorticity wave, 93, 95–97, 103, 116, 167, 185, 187  
  
 wave  
     stable, 65  
     Eady, 209, 212

- gravity, 31, 116, 122, 125, 126  
interaction, 124, 125, 187, 189  
internal, 116  
isolated, 98  
phase locked, 98  
Rossby, 96  
solitary, 117  
vorticity, 93, 95–97, 103, 116, 167, 185, 187  
wave interaction, 99, 189  
wave resonance, 91, 97, 189  
wave vector, 29, 59  
wavenumber, 29, 67

