

Index

A

Acoustic analogy
 mentioned acoustic analogy, 444
Acoustic attenuation, 15
Acoustic disturbances, 451, 402
Acoustic field, 151, 357, 359–365, 367, 368, 371–373, 379, 382, 390, 392, 396–400, 404, 420, 424–426, 431, 433, 441, 444–446, 449, 450, 470, 492, 505, 510, 512, 513
Acoustic measurements, 364
Acoustic pressure fluctuation
 instantaneous pressure fluctuation, 453
 mean pressure, 453, 454
Acoustic signal, 375
Acoustic signal propagation, 12, 121
Acoustic source mechanisms, 372
Acoustic splitting method
 viscous splitting method, 445, 449
Acoustic wave equation, 357, 450
Acoustic wave propagation, 358, 363, 367, 370, 371, 403, 405, 420, 424, 433, 444
Adaptive numerical diffusion, 381–383, 407
Aeolian tones, 449, 450, 458, 485
Aeroacoustic problems, 377, 402, 445
Aeroelastic buffet, 278
Aerofoil
 AG24 airfoil, 97, 215–218
 camber, 49
 center of pressure, 68
 circular arc airfoil, 62
 NACA 0012 airfoil, 249–251, 253, 270, 278, 281–283, 285–298, 303–307, 309–315, 317, 322, 325
 NACA 8504 airfoil, 201–203, 206
 NLF airfoil, 270

 SHM-1 airfoil, 207, 209, 249, 250, 252, 281, 299–302
 symmetric flat plate airfoil, 57, 61, 62
Aeronautical devices, 32
Analytic functions, 17, 18, 20, 42, 88
Angular deformation, 7
Angular rotation rate, 9, 73
Anti-diffusion, 137, 142, 143, 183, 253
Antisymmetric part, 6
Application of conformal transformation, 44
Applied general strain, 6
Arbitrary axis, 9
Arbitrary point, 22, 48, 52, 59, 255
Argand diagram
Artificial diffusion term, 251, 256, 324
Atmospheric pressure, 357, 358, 360, 367, 379, 390
Atwood number, 14
Auxiliary conditions
 boundary conditions, 246
 far-field boundary condition, 247
 initial conditions, 246
 Neumann and Robin conditions, 246
 periodic boundary conditions, 247
Axi-symmetric approximation, 396
Azimuthal components, 35, 112

B

Barrier
 no-barrier, 399
Baroclinic source term
 item Bauer-Garabedian-Korn
Bernoulli's equation, 26, 28, 31, 35, 55
Bi-Conjugate Gradient Stabilized method (Bi-CGSTAG), 146, 214
Biot–Savart law, 73, 74

- Blasius' theorem, 27, 29, 30, 115
 - Bluff body, 26, 433, 441, 443, 449, 458, 465, 470, 475, 476, 483, 488, 511, 512
 - Body force, 5, 124, 242, 368, 372
 - Bottom wall, 399
 - Boundary conditions
 - far-field boundary conditions, 247
 - inflow boundary, 248
 - outflow boundary, 248
 - periodic boundary conditions, 247
 - wall boundary conditions, 246
 - Bound vortex element
 - starting vortex element, 72
 - trailing vortex element, 72
 - Boyle's law, 2
 - Buffer zone, 451
 - Bulk viscosity, 12, 13, 17, 119–123, 372
 - Bypass transition
 - by convecting vortex, 222
- C**
- Cartesian components, 27, 243, 247
 - Cartesian coordinates, 23, 388, 445
 - Cartesian frame, 239, 240
 - Cartesian system, 21
 - Cartesian tensor, 9
 - Cauchy equation, 5, 8
 - Cauchy–Riemann relations, 18, 42, 200
 - Cauchy's Integral Theorem, 18
 - Cauchy's residue theorem, 20, 30
 - Circular arc airfoil, 46, 62–65
 - Circular cylinder, 25, 26, 41, 44, 46–50, 62, 392, 442, 446–451, 460, 470, 483–488, 492, 495, 498, 501, 504
 - Circular frequency, 134, 157, 281, 375, 376, 388, 412, 431
 - Circulation magnitude, 31–33
 - Closed contour, 18, 20, 29, 72
 - Compact schemes, 138–145, 151, 164, 165, 186, 187, 191, 222–224, 250–252, 254, 272, 281, 322, 380, 424, 452, 453
 - Complementary vorticity transport, 17
 - Complex analysis, 18
 - Complex function $f(z)$, 19, 41
 - Complex potential, 17, 20, 21, 24, 25, 29, 30, 41, 52, 88, 104, 105, 114
 - Complex turbulent flows, 380
 - Complex velocity, 20, 30, 43, 52, 53
 - Components of vector potential, 17
 - Compressibility states, 2
 - Compressible flows, 12, 15, 119, 120, 123, 178, 239, 242, 246, 249, 251, 263, 272, 276, 281, 303, 322, 330, 441, 445
 - Computational acoustics problem, 359, 367, 377, 391, 406, 412, 422
 - Computational Aeroacoustics (CAA) simulation, 358
 - Computational domain, 128, 146, 150, 187, 200, 201, 206, 213, 214, 219, 248, 249, 251, 263, 325, 385, 388, 390, 394, 396, 397, 402, 407, 415, 425, 426, 431, 452
 - Computational Fluid Dynamics (CFD) techniques, 441
 - Conjugate functions, 18, 22
 - Conservation law, 32, 241, 323, 368, 370
 - Constitutive relation, 2, 11, 119, 123
 - Continuous spectrum, 361
 - Continuum assumption, 1, 2
 - Contour integral, 19
 - Contraction, 6, 9, 372
 - Convection speed
 - mass conservation law
 - momentum conservation law
 - Coordinate directions, 4
 - Coupled compact difference scheme, 146, 148, 152, 381–383, 387, 388, 397, 406, 407, 409, 411
 - Creation of entropy gradient, 309
 - Creation of rotational effects, 303
 - Criticality, 31, 221
 - Crocco's theorem, 303
 - Cruise configuration, 17, 99, 177, 227
 - Curved walls, 392
 - Cylinder geometries, 449, 488
- D**
- D'Alembert's paradox, 31
 - Deformable fluid, 3
 - Density (ρ), 2
 - Deviatoric stress, 9, 10
 - Diagonal elements, 6, 8
 - Different levels, 41, 156, 178, 183, 271, 363, 404, 406, 427, 428, 458
 - Diffraction, 398
 - Diffusion coefficient, 154, 183, 381, 392, 409
 - Diffusive term, 273
 - Directivity pattern, 372, 373, 456, 470, 473, 474, 478, 497–501, 503, 507
 - Direct Numerical Simulation (DNS), 221, 223–226, 228, 229, 231, 233, 380, 441

Discretization methods, 156, 158, 198, 223, 380
 Discretization schemes, 136, 137, 148, 149, 255, 379, 380, 411–413, 415, 416, 420–424
 Dispersion error, 155–161, 192, 222, 265, 380, 412, 414, 424
 Dispersion relation, 133, 134, 150, 157–161, 165–167, 179–183, 214, 255, 264, 265, 375, 380, 412, 413, 433
 Dispersive
 non-dispersive system, 134, 135, 373, 375, 376
 Disturbance component, 371, 458
 Drag dipoles
 dipole sound compared, 450
 DRP nature, 380, 383, 420, 424
 DRP properties, 251, 254, 256, 282, 299, 324
 DRP schemes, 180, 181, 223, 303, 324
 DRP upwind schemes, 251
 Dynamic head, 3
 Dynamic Stall Vortex (DSV), 319, 335, 336
 Dynamic viscosity, 12, 324, 451, 452

E

Earthquakes, 358
 Effects of rigid barrier, 398
 Elasticity (E), 2, 3
 Elastic medium, 357–359
 Elementary singularities, 20, 22, 25, 36
 Elongation, 6
 Emphasize, 4, 103, 177, 178, 222
 Entropy variation, 15, 16
 Envelopes, 319, 376
 Equilibrium conditions, 15
 Equilibrium thermodynamics, 8, 10, 12, 119
 Equi-potential line, 21
 Equi-spaced grid points, 146, 147, 382, 388, 392, 396, 402, 415, 421, 424
 Estimate mean flow quantities, 445
 Estimate sound generated aerodynamically, 450
 Euler equations, 121, 178, 269, 323, 388, 390, 398, 399, 402, 445, 446
 Experimental investigation, 14
 Experimental issues, 271
 External acceleration, 14
 External perturbations, 14

F

Far-field sound, 442
 Finite difference compact schemes, 452

Flow past, 25–27, 30, 41, 49, 50, 52, 61, 63, 104, 113, 114, 178, 179, 198–200, 214, 218, 222, 239, 242, 247, 249, 263, 281, 283, 303, 321, 322, 433, 441–444, 446–451, 458, 460, 465, 466, 475, 476, 482–489, 495, 498, 501, 505, 510–515
 Fluctuating parameter, 361, 368
 Fluid element, 4–8, 360, 365, 370
 Fluid flows, 1, 8, 12, 20, 51, 119, 120, 126, 222, 357, 367–370, 372, 379–382, 441, 442, 444, 445, 451
 Fluid mechanics, 36, 119
 Force components, 27, 28, 59, 331
 Forces and moment for potential flows, 27
 Found weak compared, 442
 Fourier-Laplace amplitude
 Fourier transform, 191, 255, 266, 276, 277, 443, 465, 466, 468, 488, 489, 491, 493
 Free-stream temperature, 324, 450
 Free-Stream Turbulence (FST), 217, 234, 271
 Free-stream velocity, 103, 324, 450
 Full Potential Equation (FPE), 269

G

Galilean invariant
 Gaussian pressure distribution
 Generalized theorem
 General stress system, 3
 Global Spectral Analysis (GSA) technique
 perfectly matched layer (PML) technique, 381, 407
 Governing equations, 17, 22, 41, 43, 72, 88, 119, 127, 130, 154, 160–162, 179, 181, 198, 206, 242–245, 249, 254, 273, 280, 322–324, 376, 380, 388, 396, 405, 425, 428, 444, 452, 475
 Governing partial differential equations, 451
 Group velocities, 134, 135, 150, 165, 166, 181, 183, 188, 191, 192, 194, 223, 255, 376, 377, 415, 416, 420, 421

H

Half-saddle points, 33
 Harmonic signals, 375, 376
 Helmholtz stokes, 36, 69
 High-accuracy compact difference scheme, 381
 High-accuracy spectrally optimized upwind scheme, 382

Homogeneous, 131, 151, 158, 159, 365, 368,
374, 399, 402
Homogenize, 2
Horizontal, 25, 26, 29, 30, 47, 48, 50, 97, 99,
114, 227, 373, 383, 476, 505
Hypersonic speeds, 2
Hyper-viscosity, 166, 380

I

Identical strength m , 22
Imaginary part, 18, 20, 41, 136, 141–143,
145, 148, 156, 158, 159, 164–168,
181, 225, 227, 255, 414, 416, 476
Imaginary sphere, 363
Implicit Large Eddy Simulation (I-LES),
161, 162
Imposed strain field, 8
Impulsively started, 26
Indicates derivative, 76, 381
Infrasonic range, 357
Inhomogeneous fluid, 370
Inhomogeneous wave equation, 370–372,
444
Intensity level, 365, 481
Interface perturbations, 14
Inter-molecular, 359
Internal energy balance, 16
Inviscid fluids, 368
Iota, 17
Irrotational model, 31
Irrotational steady flows, 27
Isolated vortex
Isotropic, 9, 11, 131, 214, 254, 324
Iterative manner, 146

J

Jukowski airfoil, 46, 49, 50, 52–54

K

$\bar{\kappa}(\text{div}V)^2$, 16
Kelvin stokes, 36
Kinematic definition of vorticity, 17, 127
Kinematic interpretation, 6
Kinetic theory, 12, 121, 122
Knudsen number, 1
Kulite pressure sensors, 272, 276, 277
Kutta–Jukowski theorem, 30, 31, 51, 53, 55,
82

L

Laplace's equation, 17, 22, 36, 41, 88, 178,
179
Large number, 1, 281, 360, 361, 366, 367,
375, 380, 398, 485
Last Order Center (LOC) filters, 265
Laurent series expansion, 19
Legitimate stream function, 20
Length scale, 1, 4, 32, 129, 131, 230, 249,
303, 324, 398, 444
LES and DNS approaches, 399
Lift, 30–32, 34, 36, 41, 49–53, 55, 58, 59,
62, 64, 65, 67–69, 71, 72, 76–80, 82,
83, 85, 87, 89, 97, 99, 100, 105–112,
114, 115, 177, 178, 213, 214, 217–
219, 227, 270, 274, 278, 282, 283,
317–320, 322, 326, 331, 333, 334,
337, 339, 344, 347, 350, 442–444,
447, 448, 450, 458–460, 462–467,
469, 470, 473–475, 477–482, 486,
488–495, 497–499, 501, 503, 505–
510, 513, 514
Lift and drag coefficients, 213, 227, 283,
443, 460, 463–466, 469, 470, 488,
490–494, 497, 498, 505, 513, 514
Lift coefficient
 maximum $C_{l,max}$, 53
 moment coefficient (C_m), 331, 344
Lift curve slope
 effect of aspect ratio, 87
 reduction of lift curve slope, 53
Lift generation mechanism, 30
Lift on flat plate, 59
Linearized momentum equations, 372
Longitudinal wave, 12, 358, 360, 361, 379
Low Mach numbers flow, 249, 272, 442

M

Mach numbers (M), 240, 330, 485
Macroscopic, 1, 2, 121, 123, 367
Magnitude, 13, 21, 31–33, 37, 42, 70, 103,
111, 127, 133, 220, 223, 285, 315,
359, 364, 392, 466, 470, 489, 490,
492, 495, 497, 499, 501, 506
Magnus–Robins effect, 34
Mapping circular cylinder
 ellipse
 flat plate, 44
 symmetric airfoil, 44
Maximum circulation, 34, 78
Mechanical pressure, 10–12, 121
Microfluidics, 1

- Micropascal, 360
- Modulations, 376, 490
- Momentum equation, 213, 322, 369, 372
- Monochromatic frequencies, 360
- Monopole acoustic
 - radiates acoustic, 372
- Monopole sound source, 372
- M-shape structures, 16

- N**
- Natural Laminar Flow (NLF), 198, 207, 212, 221–229, 231, 233, 270, 272, 275
- Navier–Stokes equation, 12, 13, 15, 17, 26, 32, 35, 41, 50, 97, 116, 119, 121, 123, 124, 126–128, 130, 135, 137, 148, 167, 170, 177–180, 184, 199, 206, 207, 213, 219, 221, 222, 239, 240, 242, 249, 270, 272, 273, 280–282, 322, 323, 381, 382, 407, 409, 445, 449, 450, 475, 513
- Near-boundary point, 140
- Near-field solution, 442
- Neighborhood, 19, 97
- New coupled compact difference scheme, 381, 382
- Newtonian fluids, 9, 11, 119
- Non-compact source regions, 445
- Non-conducting interface
- Non-dimensionalized, 245, 323, 393, 398, 400, 401, 409, 452
- Non-equilibrium aspect, 12
- Non-equilibrium effects, 14
- Non-equilibrium thermodynamics, 12, 13, 17, 120
- Non-periodic boundaries, 14, 15
- Non-periodic problems, 139–141, 144, 145, 147, 153, 159–162, 164–166, 253, 264, 413
- Non-sparse matrix, 141
- Non-trivial consequences
- Nonzero contribution, 19
- Non-zero elements, 8
- Normal component, 394
- No-slip boundary, 213
- NS energy
- NS formulation
- Nullified, 330
- Numerical damping, 184
- Numerical derivative, 136
- Numerical diffusion, 136, 141, 148, 150, 151, 154, 183, 184, 187, 220, 254, 270, 281, 379, 381–383, 385, 392, 410, 412, 424
- Numerical dispersion relation, 150, 157–159, 165, 166, 181–183, 264, 412, 413
- Numerical instabilities, 142, 150, 160–162, 166, 167, 264, 269, 324, 379–381, 383, 394, 446
- Numerical phase speed, 158, 159, 165, 166, 183, 255, 412
- Numerical propagation speed, 380
- Numerical schemes, 141, 142, 147, 148, 150, 154, 180, 181, 183, 250, 251, 254, 265, 300–302, 379–382, 388, 412, 505
- Numerical solution of propagation, 230, 379
- Numerical stabilization, 142, 143, 379
- Nyquist limit, 135, 137, 148, Nyquist limit 165–170, 266, 268, 269, 413

- O**
- O-grid topology, 206, 451
- Oscillating circular piston, 382, 396

- P**
- Parabolized Stability Equation (PSE)
- Parallelepiped, 3
- Partial derivatives, 5, 6, 18, 199
- Periodic boundary conditions, 246, 247
- Perturbation equation, 441, 445
- Perturbation quantities, 445
- Perturbation velocity field, 369
- Perturbed Compressible Equations (PCE), 446
- Perturbed Euler Equations (PEE), 444–446
- Phase velocity, 374, 375, 415
- Physical diffusion process, 381
- Physical dispersion relation, 134, 150, 157, 158, 180, 373, 375, 380, 412, 420
- Physically involves compression, 12
- Physical nature, 50, 278, 375
- Physical velocity, 134, 181, 183, 379
- Piston oscillates, 360, 397
- Piston surface, 360, 397
- Pitching moment, 27, 28, 55, 59–61, 64, 68, 97, 99, 100, 177, 178, 318–320, 331, 333, 344, 347, 350
- Polyatomic molecules, 13
- Positioning
- Positive and negative powers of $(z - z^*)$, 19
- Postulated, 11
- Powells vortex sound theory, 444
- Prandtl reasoned, 34
- Prandtl's limit, 32, 34, 35

- Prandtl's number (Pr), 240, 451, 485
 Preliminaries, 18, 177, 178
 Preserves shape, 6
 Pressure (p)
 pressure distribution, 27, 35, 36, 53, 54, 97, 99, 101, 108, 109, 111, 177, 178, 280, 285, 326, 512
 pressure fluctuations around, 453
 pressure fluctuations associated, 370, 379
 pressure peaks measured, 453
 pressure pulse, 303, 360, 395, 397, 405, 406, 470, 471, 476, 492, 494–496, 501, 505
 Primary singularities, 20
 Produce acoustic field, 373
 Propagate through, 360, 366
 Propagation
 entropic disturbances, 405, 406, 408
- Q**
 Quadrupolar component, 442
 Quadrupolar sound, 442
 Quadrupole source consists, 373
 Quantities, 4, 25, 31, 50, 92, 105, 115, 122, 127, 134, 136, 156, 170, 171, 183, 213, 245, 264, 265, 276, 362, 363, 368, 369, 371, 398, 402, 414, 416, 441, 442, 444–447
- R**
 Radial component, 21, 396
 Radial direction, 363, 394, 395
 Radiates acoustic, 366, 372
 Radiates power, 362
 Radiating acoustic waves, 363
 Radiation boundary condition, 394, 398, 402, 403
 Radical sign, 31, 105
 Radius R centered, 19
 Random molecular motion, 2
 Ranges of acoustic zone, 451
 RANS and DNS compressible, 272, 274, 276, 277
 Rayleigh–Taylor Instability, 12–16, 123
 Recirculating streamline, 34
 Recognized, 360, 450
 Rectangular element, 7
 Refined grid point distribution, 451
 Reflection case, 365, 388
 Reflection of pressure waveform, 388
 Reflective symmetry, 9
- Regardless, 361
 Relative motion, 5, 6, 8
 Relative velocity components, 6
 Remaining fraction, 365
 Repeatedly, 366
 Resolved wavenumber components, 379
 Resultant stresses, 3
 Reynolds-Averaged Navier–Stokes (RANS), 99, 100, 177, 178, 249, 263, 269, 272–276, 278, 322, 399
 Reynolds number (Re_∞), 1, 17, 52, 61, 97, 129, 131, 213, 216–220, 222, 224, 227, 239, 240, 278, 280, 281, 319, 330, 342, 409, 442, 443, 446, 447, 449–453, 458, 484–486, 491, 510–513
 Rigid body rotation, 7–9
 Ripples propagate, 358
 Role of bulk viscosity, 14
 Rolling moment (L_R), 85, 86
 Root Mean Square (RMS), 227, 228, 272, 276, 361, 364, 365, 399, 401, 433, 456–460, 462, 470, 473, 474, 482, 497, 498, 500, 501, 503, 505
 Rotating cylinder, 30, 34, 35
 Runge–Kutta method, 185, 251, 273, 416, 452
- S**
 Scattering, 360, 365, 366, 392, 394
 Second coefficient, 12, 13, 15, 122, 123
 Second derivative, 135, 137, 138, 143–145, 148, 150, 263, 266, 381, 382, 409
 Second-order accurate, 253, 442
 Shear stresses denoted, 3
 Shock–boundary layer, 132, 270, 278, 279
 Shortcoming, 12, 121
 Signal amplitude, 374, 376
 Signal propagation, 199, 373
 Significantly reduced, 399
 Simultaneous evaluation, 146
 Single component perpendicular, 17
 Singularities, 19–21, 25, 29, 30, 37, 43, 44, 50, 51, 69, 89, 90, 96, 99, 102
 Singular points of W
 Slender wing theory, 103–106, 108, 113
 Smallest recognizable, 379
 Smoothly, 51, 52, 200, 203, 230, 358, 409
 Smooth wave packet, 382, 383
 Sokolnikoff, 9
 Solution of incompressible viscous equation, 445

Sound generated, 441–443, 450, 481, 503
 Sound generation effects, 487
 Sound intensity, 362–365, 482, 497
 Sound power, 362, 363, 365
 Source and sink pair, 20
 Source and sink vanishing, 23
 Spalart–Allmaras (S-A), 270, 322
 Species mass fraction transport equation
 Specific finite difference scheme, 381
 Spectral resolution, 138, 139, 147, 148, 299,
 380, 383, 387, 412–414
 Spectral vanishing viscosity method, 380
 Speed V , 3
 Spherical wave equation, 388
 Spikes and bubbles, 16
 Spinning and translating cylinder, 35
 Spinning cylinder, 30
 Spurious dispersion, 224, 379, 380
 Square root, 17, 361
 Stagnation point, 25, 26, 30–34, 36, 50–53,
 57, 58, 63, 88, 97
 Starting boundary
 near boundary nodes, 413
 near boundary points, 163, 164, 253
 Stokes' hypothesis, 11–13, 15, 16, 41, 119,
 121, 123
 Strain rate, 5, 9, 51
 Strain tensor, 6, 8–10, 51, 119
 Stratosphere, 2
 Stream function ψ , 17, 25, 41, 322
 Streamlined bodies, 60, 441, 510–513
 Streamline precludes, 33
 Stress–strain system, 1
 Stress tensor, 4, 5, 8, 243, 323, 371, 442, 446,
 447, 485
 Strictly azimuthal, 21
 Strong conservation, 241, 242, 323
 Strong shock, 270, 303, 309, 324, 330, 342
 Strouhal frequency, 453, 454
 Studying aerodynamic flows, 2
 Sufficiently, 13, 51, 184, 279, 319, 370, 512
 Supercritical rotation, 35, 36
 Superimposed signal causing formation, 376
 Superposing solutions, 22
 Super-sonic mean flows, 402
 Symmetric part, 6, 9

T

Tangential component, 37, 99
 Taylor series approximations, 146, 147, 416
 Temperature (T), 2, 324
 Temporal derivatives, 452

Tensorial notation, 370, 372
 Tetradic (C), 9
 Thermal conductivity, 125, 240, 280, 370,
 452, 485
 Thermodynamic pressure, 8, 10
 Thermodynamic properties, 2
 Thermodynamic speed, 370
 3D flow field, 17
 Time-accurate solution, 199, 221, 239, 280,
 282, 475
 Time scale, 122, 130, 132, 133, 150, 179,
 398, 409
 Total energy, 125, 452
 Total internal energy, 240
 Traditional explicit schemes, 380
 Traditional Gauss–Seidel iterative algorithm,
 146
 Transonic flow, 132, 247, 263, 269–271, 278,
 279, 281, 319
 Transonic Small-Disturbance (TSD), 269
 Transport process, 12
 Transport properties, 451
 Triggered either, 357, 367
 Trigonometric identity, 23, 68
 2D Formulation, 127

U

Unboxed loudspeaker, 373
 Uniform flow, 20, 25, 29, 34, 167, 235, 282,
 409, 410, 445, 485, 486, 488
 Uniform grid, 136, 156, 167, 170, 266, 412
 Uniform horizontal stream, 25, 26
 Uniformly moving medium, 450
 Uniform wind, 20
 Universal gas, 2, 240, 452

V

Valid velocity potential, 20
 Variation of RMS value, 227, 401
 Various coefficients, 146
 Various existing numerical, 380
 Various frequencies, 375, 448
 Various levels, 364
 Various Reynolds number, 451, 453
 Vector potential, 17, 127, 128
 Velocity components, 6, 10, 21, 26, 37, 90,
 92–95, 99, 103, 105, 127, 180, 240,
 247, 324, 447
 Velocity gradient tensor, 9
 Velocity potential, 17, 41, 70, 89, 105, 114
 Velocity scale, 398, 409
 Velocity–vorticity formulation, 127

Vertical wavefronts, 373
Vibrating surface, 357, 367
Violation, 34
Virtually negligible, 16
Viscosity, 12, 13, 15, 121–123, 129, 180,
243, 245, 270, 280, 324, 367, 368,
379, 420, 424, 485
Volume (V), 2
Vortex-induced instability, 221
Vorticity identically zero, 8
Vorticity vector defined, 6

W

Wall surface, 397

Wave equation, 150–153, 155, 357, 370–
376, 382, 383, 399, 407, 412, 413,
417, 419–421, 442
Wide-band spectrum, 134, 276
WTEA-TE1 airfoil, 210–213, 249, 272–276

Y

Yawing moment (N), 85, 86

Z

z -component, 8

Zero wall-normal velocity, 37