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Autore	Mohammadi B
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Nota di contenuto	Contents; 1 Introduction; 2 Optimal shape design; 2.1 Introduction; 2.2 Examples; 2.2.1 Minimum weight of structures; 2.2.2 Wing drag optimization; 2.2.3 Synthetic jets and riblets; 2.2.4 Stealth wings; 2.2.5 Optimal breakwater; 2.2.6 Two academic test cases: nozzle optimization; 2.3 Existence of solutions; 2.3.1 Topological optimization; 2.3.2 Sufficient conditions for existence; 2.4 Solution by optimization methods; 2.4.1 Gradient methods; 2.4.2 Newton methods; 2.4.3 Constraints; 2.4.4 A constrained optimization algorithm; 2.5 Sensitivity analysis 2.5.1 Sensitivity analysis for the nozzle problem2.5.2 Numerical tests with freefem++; 2.6 Discretization with triangular elements; 2.6.1 Sensitivity of the discrete problem; 2.7 Implementation and numerical issues; 2.7.1 Independence from the cost function; 2.7.2 Addition of geometrical constraints; 2.7.3 Automatic differentiation; 2.8 Optimal design for Navier-Stokes flows; 2.8.1 Optimal shape design for Stokes flows; 2.8.2 Optimal shape design for Navier-Stokes flows; References; 3 Partial differential equations for fluids; 3.1 Introduction; 3.2 The Navier-Stokes equations

3.2.1 Conservation of mass3.2.2 Conservation of momentum; 3.2.3 Conservation of energy and and the law of state; 3.3 Inviscid flows; 3.4 Incompressible flows; 3.5 Potential flows; 3.6 Turbulence modeling; 3.6.1 The Reynolds number; 3.6.2 Reynolds equations; 3.6.3 The  $k$  - model; 3.7 Equations for compressible flows in conservation form; 3.7.1 Boundary and initial conditions; 3.8 Wall laws; 3.8.1 Generalized wall functions for  $u$ ; 3.8.2 Wall function for the temperature; 3.8.3  $k$  and  $\epsilon$ ; 3.9 Generalization of wall functions; 3.9.1 Pressure correction 3.9.2 Corrections on adiabatic walls for compressible flows3.9.3 Prescribing  $\left[\text{sub}(w)\right]$ ; 3.9.4 Correction for the Reichardt law; 3.10 Wall functions for isothermal walls; References; 4 Some numerical methods for fluids; 4.1 Introduction; 4.2 Numerical methods for compressible flows; 4.2.1 Flux schemes and upwinded schemes; 4.2.2 A FEM-FVM discretization; 4.2.3 Approximation of the convection fluxes; 4.2.4 Accuracy improvement; 4.2.5 Positivity; 4.2.6 Time integration; 4.2.7 Local time stepping procedure; 4.2.8 Implementation of the boundary conditions  
4.2.9 Solid walls: transpiration boundary condition4.2.10 Solid walls: implementation of wall laws; 4.3 Incompressible flows; 4.3.1 Solution by a projection scheme; 4.3.2 Spatial discretization; 4.3.3 Local time stepping; 4.3.4 Numerical approximations for the  $k$  - equations; 4.4 Mesh adaptation; 4.4.1 Delaunay mesh generator; 4.4.2 Metric definition; 4.4.3 Mesh adaptation for unsteady flows; 4.5 An example of adaptive unsteady flow calculation; References; 5 Sensitivity evaluation and automatic differentiation; 5.1 Introduction; 5.2 Computations of derivatives; 5.2.1 Finite differences  
5.2.2 Complex variables method

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#### Sommario/riassunto

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Examining shape optimization problems for fluids, with the equations needed for their understanding and the simulation of these problems, this text introduces automatic differentiation approximate gradients, and automatic mesh refinement.

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