Non-primitive variables (stream function and vorticity) for solution to two-dimensional fluid flow and heat transfer problems

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Abstract. Analysis of fluid flow and heat transfer in the case of complex physical boundary conditions is related to an application of numerical methods of mathematical physics. One of these numerical methods is a finite difference method. It is well-known that the direct use of this technique for solution to the Navier-Stokes equations combined with energy equation has essential difficulties due to the lack of the pressure equation. Therefore, the majority of the developed CFD packages for solution to fluid flow and heat transfer problems are based on the finite volume method. At the same time, in the case of 2D problems it is possible to transform the original Navier-Stokes equations to the form excluding the pressure field that allows reducing significantly the computational time. Such approach deals with an introduction of stream function and vorticity variables. During the first lecture the transformation of governing equations will be presented combined with original difference schemes for an approximation of convective and diffusive terms to solve 2D boundary-value problems. As an illustration some interesting problems on natural convection in regular and irregular, single- and double-connected domains filled with porous medium or nanofluid will be considered.

Keywords: 2D boundary-value problem, stream function, vorticity, finite difference method, natural convection