INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: **Development of compact schemes for the biharmonic form of Navier-Stokes equations on compact nonuniform grids without transformation**

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SHORT ABSTRACT

This work is concerned with developing compact finite difference schemes for simulating incompressible viscous flows governed by the Navier-Stokes (N-S) equations on non uniform grids without transformations. The main work is concerned with developing two efficient schemes, one for the steady-state form of the N-S equations and the other one, is for its transient counterpart. They are developed for the the pure stream function formulation of the N-S equations, and second order accurate in both time and space. Apart from simulating several complex fluid flow situations for validating our schemes, emphasis is given more on simulating flow past bluff bodies, which finds wide ranging applications in laboratories and industries. In the process, numerical rate of convergence of the schemes and grid independence of the computed solutions are also established. Comprehensive analysis is carried out for the flow past stationary, rotating and oscillating circular cylinders in uniform flows for moderate Reynolds numbers (*Re*) and starting flow for the stationary case for high *Re*s. For the stationary case, high quality simulations are accomplished for a wide range of *Re*s ranging from $10^0 \leq \mathrm{Re} \leq 10^4$ in the laminar regime, including the periodic flow characterized by von Kàrmàn vortex street. The α, β, sub-α and sub-β phenomena, which are the trademark of the secondary and tertiary vortex dynamics associated with such flows, are studied in detail. However, the highlight of the thesis is the simulation of flow past sharp edges in uniform and accelerated flows, where we have considered the flat plate and a suspended wedge as our test cases. For the flat plate, several modes of vortex shedding patterns are established through a comprehensive FFT analysis. For the wedge, onset of turbulence is verified by the presence of coherent and three-fold structures in the flow. Moreover, the proposed schemes have also been utilized to accurately simulate heat transfer problems, including conjugate heat transfer problems in suddenly expanding channels. In all the cases, our numerical results are seen to be extremely close to the available numerical and experimental results.