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ANALYTICAL–NUMERICAL INVESTIGATION OF LIFTING AND NON-LIFTING POTENTIAL FLOW AROUND A CIRCULAR CYLINDER

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Abstract:
This study presents an analytical–numerical investigation of two-dimensional incompressible potential flow around a circular cylinder under both non-lifting and lifting conditions. Closed-form expressions for velocity components and pressure coefficient are derived through the superposition of uniform flow, doublet, and point-vortex elements. A MATLAB-based numerical framework is developed to compute velocity fields, streamline patterns, stagnation-point locations, surface pressure distributions, and lift coefficients over a wide range of circulation strengths ($-4 \leq \Gamma \leq 4$). A systematic parametric study demonstrates a linear dependence between lift coefficient and circulation, in accordance with the Kutta–Joukowski theorem, and quantitatively describes the migration of stagnation points, growth of velocity asymmetry, and variation of maximum surface velocity with circulation. Numerical results are validated against analytical solutions, yielding relative errors below 3% for all tested cases. Although the governing theory is classical, the present work provides a unified, reproducible benchmark dataset and visualization framework that can be used for verification of numerical solvers and for educational and preliminary aerodynamic design purposes.

Keywords:
Potential Flow, Circular Cylinder, Circulation, Lift Coefficient, Stagnation Point, MATLAB Simulation, Kutta–Joukowski Theorem

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