2.25

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10 Potential Flow, Lift, and Drag

10.1 The occurrence of irrotational (potential) flows. The definition of the velocity potential ϕ.

10.2 Incompressible potential flows as solutions of Laplace's equation for the velocity potential with $\partial\phi/\partial n$ specified at the boundaries (the "Neumann problem").

10.3 The equation for the pressure distribution (Bernoulli's integral in terms of ϕ).

10.4 An example: The solution for 2D potential flow over a cylinder. Comparison with experimental data at high Reynolds number, where the flow might be expected to be reasonably "inviscid." Discussion of the pitfalls of potential flow theory.

10.5 [Two-dimensional potential flows. Analytical solutions for simple 2D flows: parallel uniform flow, line source or sink, line vortex. Superposition of simple elemental flows as representations of flows over 2D bodies.]

10.6 Three properties of ideal potential flows around 2D bodies in an infinite stream: (a) The nonexistence of drag (D'Alembert's paradox), (b) the relation between lift and circulation around the body (Kutta-Joukowsky theorem), and (c) the indeterminacy of the circulation in 2D potential flow theory.

10.7 The Kutta condition: an ad hoc criterion, derived from experimental observation, that allows potential flow analysis to be used to establish the circulation (i.e. lift) for a 2D shape *with a sharp trailing edge*.

10.8 Comments on the fact that viscosity, no matter how "small" it may be in a high Reynolds number flow, is responsible—by causing separation!—for the existence of both lift and drag.

10.9 Qualitative picture of the 3D flow field over a finite lifting surface (wing). Wing-tip vortices, downwash, etc. Induced drag.

10.10 Overview of lift and drag forces on lifting surfaces.

<u>Read</u>**:** Fay, Chapter 11, Kundu Chapter 6
or, for example, Potter & Foss, pp. 360-390, 454-468