DEPARTMENT OF AEROSPACE ENGINEERING

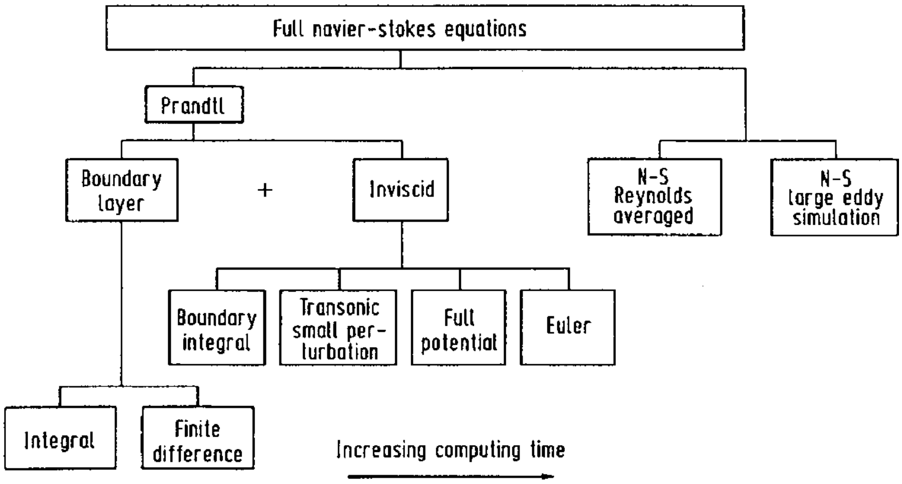
Faculty Name	:	**Dr.A.Arun Negemiya, ASP/ Aero**	Academic Year	:	**2024-2025 (Even)**
Year & Branch	:	**III AEROSPACE**	Semester	:	**VI**
Course	:	**19ASB304 - Computational Fluid Dynamics for Aerospace Application**			

UNIT II – DISCRETIZATION

Implicit Time-Dependent Methods for Inviscid and Viscous Compressible Flows

The compressible Euler and Navier-Stokes equations represent the most sophisticated models of single-phase flows of single-component Newtonian fluids. As such, they allow the analysis of complex Inviscid and viscous flow phenomena including rotational flows caused by curved shock waves or viscous/Inviscid interactions leading to flow separation. As a counterpart, the numerical techniques required to solve these equations are also the most sophisticated and the numerical effort needed to obtain them is also the greatest. The difficulties of solving complex steady compressible flows were already pointed out in the first part of this volume, in which the blunt-body problem was taken as an illustrative example. It was shown that the crux of the difficulty lies in the mixed character of the flow, involving regions governed by ―elliptic‖ equations and others governed by ―hyperbolic‖ equations. Finally, the solution to the problem was found by solving the time-dependent equations using a time marching method, taking advantage of the uniform nature of the unsteady equations concerning time, independently of the subsonic or supersonic character of the flow.1 following that breakthrough, many methods were developed to integrate the unsteady Euler or Navier-Stokes equations. These methods can be classified into two main categories: explicit and implicit methods.

Historically, explicit methods were developed earlier, because of their greater simplicity. The major limitation of these methods is their stability characteristics which impose an upper bound on the usable integration time step. In recent years, implicit methods have been developed to overcome this limitation and have proved more efficient than the former explicit method, which justifies their study.



Hierarchy of computational fluid dynamics after Discretization

We shall examine solution techniques for simpler flows and explain why these techniques fail for the solution of the steady compressible Euler/ Navier-Stokes equations. The stability properties of numerical integration techniques will be studied in detail first for ordinary differential equations, and then for partial differential equations. It will be shown how an implicit method can be constructed to solve partial differential equations such as the Euler or Navier-Stokes equations. It will be seen that this can be subdivided into three steps, the choice of an explicit discretization scheme, the choice of an implicit operator, and finally the choice of a solution strategy, which will be discussed in turn. For the first step, the issue of numerical dissipation will turn out to be crucial, and this concept will be discussed in detail. As in Part I, only the finite difference method is considered as the space discretization technique, but, as will be mentioned in the lecture, most of the concepts discussed and of the basic methods described apply equally to finite volume discretizations (especially on structured meshes) and some to finite element discretizations.