



SNS COLLEGE OF TECHNOLOGY

(An Autonomous Institution)
COIMBATORE -641035



Finite Volume Techniques - Cell centered formulation

In finite volume techniques, the cell-centered formulation is one of the common approaches used for discretizing partial differential equations (PDEs) over a computational domain. Here's a breakdown of how it works:

Overview:

Discretization of the Domain:

The computational domain is divided into a mesh/grid composed of cells or control volumes. Each cell represents a volume in the domain.

Cell-Centered Approach:

In the cell-centered approach, the primary unknowns (such as the values of the dependent variables) are located at the center of each cell. This means that the variables are approximated within the volume of the cell itself.

Conservation Principles:

Finite volume methods are built on the principles of conservation of mass, momentum, and energy. The discretization process ensures that these conservation principles are accurately represented at the discrete level.

Integral Form of the Governing Equations:

The governing equations (e.g., conservation laws) are typically written in integral form over each control volume. These equations represent the balance of quantities (e.g., mass, momentum, energy) entering and leaving the control volume.

Spatial Discretization:

The integral equations are then spatially discretized over each control volume. This involves approximating the integrals using numerical quadrature techniques.

Linear System of Equations:

The discretized equations result in a system of algebraic equations, typically represented in matrix form. This system needs to be solved to obtain the solution within each cell.

Steps in Cell-Centered Finite Volume Method:

Grid Generation:

Generate a grid that covers the computational domain. This can be structured (e.g., Cartesian) or unstructured (e.g., triangular or tetrahedral).

Control Volume Definition:

Define control volumes around each grid cell. These control volumes are used to perform the spatial discretization of the governing equations.

Governing Equation Discretization:

Discretize the governing equations (e.g., conservation laws) over each control volume using techniques like the divergence theorem or Green's theorem.

Boundary Conditions:

Apply appropriate boundary conditions at the interfaces between cells or at the domain boundaries.

Linear System Solution:

Assemble the discretized equations into a linear system and solve it using numerical methods like iterative solvers or direct solvers.

Solution Reconstruction:

Once the solution values are obtained at the cell centers, they can be interpolated to obtain values at other points of interest, such as cell faces or nodal points.

Advantages:

Conservation Properties: Cell-centered formulations naturally preserve conservation properties.

Flexibility: Can be applied to various types of grids, including structured and unstructured grids.

Simple Implementation: Conceptually straightforward to implement, especially for structured grids.

Limitations:

Numerical Diffusion: Can introduce numerical diffusion, particularly in high-gradient regions.

Stability: Depending on the scheme used, stability issues may arise, especially for convection-dominated problems.

Grid Quality: Performance may depend on the quality of the grid, particularly for unstructured grids.

Overall, the cell-centered finite volume method is widely used due to its simplicity, conservation properties, and flexibility across different types of grids. However, proper consideration of numerical schemes, grid quality, and stability is crucial for accurate and reliable simulations.