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 IV – FINITE VOLUME TECHNIQUES

Importance of Central and Upwind Discretization

Central and upwind discretization schemes are crucial in numerical methods, especially in Computational Fluid Dynamics (CFD), with central schemes offering higher accuracy but potentially instability, while upwind schemes prioritize stability and are better at capturing discontinuities but can introduce numerical diffusion.

Here's a more detailed explanation:

Central Discretization:

- **Accuracy:**

  Central schemes, which use information from both sides of a grid point, generally provide higher accuracy for smooth flow regions compared to upwind schemes.

- **Stability:**

  However, central schemes can become unstable for certain flow conditions, particularly when dealing with strong convection or high Peclet numbers (a measure of the ratio of convection to diffusion).

- **Diffusion:**

  Central schemes can introduce numerical diffusion, which can smear out sharp gradients and discontinuities in the solution.

Upwind Discretization:

- **Stability:**

  Upwind schemes, which use information from the upstream side of a grid point, are generally more stable than central schemes, especially for problems with strong convection.

- **Discontinuities:**

  Upwind schemes are better at capturing discontinuities (like shocks) in the flow, as they inherently favor the direction of the flow.

- **Accuracy:**

  However, upwind schemes can introduce numerical diffusion, which can smear out sharp gradients and discontinuities in the solution.

- **First-order vs. Higher-order:**

  First-order upwind schemes are known for their stability but can be less accurate, while higher-order upwind schemes (e.g., second-order upwind) require limiters to prevent oscillations near discontinuities.

Hybrid Schemes:

- Some schemes combine central and upwind techniques to achieve a balance between accuracy and stability. The hybrid difference scheme, for example, uses the central difference scheme for small Peclet numbers and the upwind scheme for large Peclet numbers.
- Another example is the use of limiters in higher-order upwind schemes to prevent spurious oscillations near discontinuities.