



SNS COLLEGE OF TECHNOLOGY

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DEPARTMENT OF AEROSPACE ENGINEERING

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Course : **19ASB304 - Computational Fluid Dynamics for Aerospace Application**

UNIT III – FINITE ELEMENT TECHNIQUES

Comparison of FEM with Finite Volume and Finite Difference Methods

Here's a consolidated comparison, emphasizing their core differences and applications:

Key Distinctions:

- **Formulation:**
 - **FDM (Finite Difference Method):**
 - Relies on approximating derivatives directly using Taylor series expansions.
 - Works with the differential form of the governing equations.
 - **FVM (Finite Volume Method):**
 - Focuses on the integral form of conservation laws.
 - Ensures that quantities like mass, momentum, and energy are conserved within each control volume.
 - **FEM (Finite Element Method):**
 - Based on variational formulations (weak forms) of the governing equations.
 - Approximates solutions using shape functions within elements.
- **Grid/Mesh:**
 - **FDM:**
 - Typically uses structured grids (e.g., Cartesian).
 - Can be challenging to apply to complex geometries.

- **FVM:**
 - Can handle both structured and unstructured grids.
 - Highly adaptable to complex geometries.
- **FEM:**
 - Also works with both structured and unstructured meshes.
 - Excels in handling complex geometries.
- **Conservation:**
 - **FDM:**
 - Conservation is not inherently guaranteed.
 - **FVM:**
 - Strongly conservative, making it ideal for fluid flow problems.
 - **FEM:**
 - Conservation properties vary depending on the specific formulation.
- **Applications:**
 - **FDM:**
 - Simpler problems on regular geometries (e.g., basic heat transfer).
 - **FVM:**
 - Computational Fluid Dynamics (CFD), heat transfer, and other conservation-focused problems.
 - **FEM:**
 - Structural analysis, solid mechanics, heat transfer, electromagnetics, and some CFD applications.

In simpler terms:

- Imagine dividing a pizza.
 - FDM: You're focused on the differences in toppings between tiny squares on the pizza.
 - FVM: You're making sure each slice (volume) has the correct amount of each topping.
 - FEM: You're fitting flexible shapes (elements) onto the pizza to approximate its overall form.

Key Takeaways:

- FVM is dominant in CFD due to its strong conservation properties.

- FEM is highly versatile for problems involving complex geometries.
- FDM is simple but limited to simpler cases.

Applications of Each Method

Practical Applications of FEM

All kinds of structural analysis, heat transfer, chemical engineering, electromagnetics (including electrostatics, magnetostatics, low-frequency electromagnetics, and frequency-domain high-frequency electromagnetic waves), multi-physics, and CFD.

Use Cases for FDM

Weather calculations, astrophysics, seismology, physical realism in computer graphics, and special effects.

FVM in Real-World Scenarios

CFD, heat transfer, and chemical engineering.