19ASB304 - COMPUTATIONAL FLUID DYNAMICS FOR AEROSPACE APPLICATION

Question Bank

UNIT I - FUNDAMENTAL CONCEPTS

Part A – 2 Mark Questions

(Remembering, Understanding, and Applying Levels)

1. Define elliptic, parabolic, and hyperbolic equations. *(Remembering)*
2. What are the mathematical properties of fluid dynamics equations? *(Understanding)*
3. Give an example of an elliptic equation in fluid dynamics. *(Remembering)*
4. Define initial and boundary conditions in fluid flow problems. *(Understanding)*
5. What is a well-posed problem? *(Understanding)*
6. Differentiate between well-posed and ill-posed problems. *(Analyzing)*
7. What is meant by the discretization of partial differential equations? *(Understanding)*
8. Define grid generation in computational fluid dynamics (CFD). *(Remembering)*
9. What are the different types of grids used in CFD? *(Understanding)*
10. Differentiate between structured and unstructured grids. *(Analyzing)*
11. What is a multi-block grid? *(Understanding)*
12. Define hybrid grid in CFD. *(Remembering)*
13. What is an adaptive grid, and why is it used? *(Understanding)*
14. Explain the concept of meshless methods in CFD. *(Understanding)*
15. What is the explicit finite difference method? *(Understanding)*
16. How does an implicit scheme differ from an explicit scheme? *(Analyzing)*
17. What is the significance of finite difference methods in supersonic flows? *(Applying)*
18. Define the source panel method in aerodynamic analysis. *(Understanding)*
19. What is the vortex panel method, and how is it used? *(Understanding)*
20. List the applications of panel methods in fluid flow simulations. *(Remembering)*

Part B – 16 Mark Questions

(Applying, Analyzing, Evaluating, and Creating Levels)

1. Derive and explain the classification of fluid dynamics equations as elliptic, parabolic, and hyperbolic. *(Applying)*
2. Discuss the importance of initial and boundary conditions in solving fluid flow problems. *(Analyzing)*
3. Analyze well-posed and ill-posed problems in computational fluid dynamics with examples. *(Analyzing)*
4. Explain the different methods of discretizing partial differential equations in CFD. *(Applying)*
5. Compare structured, unstructured, and hybrid grids in CFD, highlighting their advantages and disadvantages. *(Analyzing)*
6. Describe the importance of grid generation and compare single-block and multi-block grids. *(Evaluating)*
7. Discuss meshless methods and their advantages over traditional grid-based approaches. *(Evaluating)*
8. Illustrate the explicit finite difference method for solving subsonic and supersonic flows. *(Applying)*
9. Compare implicit and explicit schemes in terms of stability, accuracy, and computational cost. *(Analyzing)*
10. Explain the source panel method in aerodynamics and derive its governing equations. *(Applying)*
11. Analyze the vortex panel method and discuss its applications in flow analysis over airfoils. *(Analyzing)*
12. Evaluate the role of panel methods in computational aerodynamics and compare their efficiency with grid-based methods. *(Evaluating)*
13. Design a computational grid for simulating flow over an airfoil and justify your choice of grid type. *(Creating)*
14. Develop an explicit finite difference scheme for viscous flow problems and discuss its numerical stability. *(Creating)*
15. Propose a hybrid approach combining grid-based and meshless methods for high-speed flow simulations. *(Creating)*
16. Critically evaluate the limitations of current CFD discretization techniques and suggest possible improvements. *(Evaluating)*

UNIT II – DISCRETIZATION

Part A – 2 Mark Questions

(Remembering, Understanding, and Applying Levels)

1. Define the **boundary layer equation** in fluid dynamics. *(Remembering)*
2. What are the key **assumptions** made in boundary layer theory? *(Understanding)*
3. List different **methods for solving boundary layer equations**. *(Remembering)*
4. Define **implicit time-dependent methods**. *(Understanding)*
5. How do **implicit methods** differ from **explicit methods**? *(Analyzing)*
6. What is the significance of **numerical dissipation** in CFD? *(Understanding)*
7. Explain the concept of **stability in numerical methods**. *(Understanding)*
8. What is meant by the **stability property of an explicit method**? *(Understanding)*
9. How does **numerical dissipation affect the accuracy** of a numerical scheme? *(Applying)*
10. What are the advantages of **implicit time-dependent methods** for compressible flows? *(Understanding)*
11. Define a **conservative upwind discretization scheme**. *(Understanding)*
12. Why are **upwind schemes preferred for hyperbolic systems**? *(Understanding)*
13. Differentiate between **upwind and central differencing schemes**. *(Analyzing)*
14. What is a **hyperbolic system in fluid dynamics**? *(Understanding)*
15. Explain the term **conservative discretization**. *(Understanding)*
16. How does **upwind differencing help in reducing numerical oscillations**? *(Analyzing)*
17. What are the key **advantages of upwind differencing** over other discretization schemes? *(Analyzing)*
18. Define **viscous and inviscid compressible flow**. *(Understanding)*
19. What are the main **challenges in solving boundary layer equations numerically**? *(Analyzing)*
20. What is **artificial viscosity**, and how does it relate to numerical dissipation? *(Understanding)*

Part B – 16 Mark Questions

(Applying, Analyzing, Evaluating, and Creating Levels)

1. Derive the boundary layer equations and discuss different methods for solving them. ***(Applying)***

2. Compare explicit and implicit time-dependent methods for solving inviscid and viscous compressible flows. ***(Analyzing)***

3. Explain the role of numerical dissipation in computational fluid dynamics and its effect on solution accuracy. ***(Applying)***

4. Discuss the stability properties of explicit and implicit numerical methods, highlighting their advantages and limitations. ***(Analyzing)***

5. Explain conservative upwind discretization for hyperbolic systems and derive its governing equations. ***(Applying)***

6. Evaluate the importance of upwind differencing in solving hyperbolic PDEs. How does it improve numerical stability? ***(Evaluating)***

7. Analyze the advantages of implicit schemes over explicit schemes in terms of numerical stability and convergence. ***(Analyzing)***

8. Illustrate the impact of numerical dissipation in computational schemes with suitable examples. ***(Applying)***

9. Explain the challenges in solving viscous compressible flow equations and propose numerical strategies to overcome them. ***(Evaluating)***

10. Compare different upwind schemes, such as first-order and higher-order methods, in terms of accuracy and computational cost. ***(Analyzing)***

11. Develop a numerical algorithm using an upwind differencing scheme for solving hyperbolic systems. ***(Creating)***

12. Critically assess the role of artificial viscosity in numerical simulations and propose techniques to optimize its effects. ***(Evaluating)***

13. Design an implicit numerical method for solving boundary layer equations in high-speed flows. ***(Creating)***

14. Propose a hybrid numerical scheme that combines explicit and implicit methods for improved stability and accuracy. ***(Creating)***

15. Discuss the real-world applications of upwind differencing in aerospace and computational fluid dynamics. ***(Evaluating)***

16. Evaluate the impact of numerical errors in boundary layer solutions and suggest approaches to minimize them. ***(Evaluating)***