

GUJARAT TECHNOLOGICAL UNIVERSITY

BE-6 SEMESTER – OLD PAPER – S22 TO W25 – QUESTION BANK

Subject Name & Code:

COMPUTATIONAL FLUID DYNAMICS- 3161915

Unit 1: Introduction to CFD & Principles of Conservation

Repeated Questions:

1. Define CFD. (S22 - Q1a, 03 marks)
(Also asked as: *What is CFD?* in S23, W23, W24, S25)
2. Explain Reynolds transport theorem. (W24 - Q1a, 03 marks)
(Also in S22, S23, W25)
3. Derive Navier-Stokes equation. (S23 - Q1c, 07 marks)
(Also in W22, W23, S25 OR)

Other Important Questions:

1. Briefly explain various steps involved in CFD analysis. (W25 - Q1a, 03 marks)
 2. What do you mean by result validation in CFD analysis? Why is it needed? (W25 - Q1b, 04 marks)
 3. Explain theoretical, experimental and numerical approach in CFD. (W25 - Q1c, 07 marks)
 4. List out basic fundamental principles utilized for CFD analysis. Explain conservation of mass principle briefly. (W25 - Q2a, 03 marks)
 5. Explain the momentum equation in non-conservation form. (S23 - Q1b, 04 marks)
 6. Derive general integrated form of the transport equation from governing equation. (S23 - Q1c, 07 marks)
 7. What are the needs for problem solving with CFD? (W23 - Q1a, 03 marks)
 8. State application of CFD in the field of aeronautical engineering. (W23 - Q1b, 04 marks)
 9. Derive Continuity equation for any model of finite control volume fixed in space. (W23 - Q1c, 07 marks)
 10. Derive energy equation in non-conservation form. (S22 - Q1c, 07 marks)
 11. What are the important applications of CFD in engineering? (W24 - Q1a, 03 marks)
 12. List down the advantages of CFD over experimental methods. (W24 - Q2a, 03 marks)
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Unit 2: Classification of PDEs & Physical Behavior

Repeated Questions:

1. Explain the classification of quasi-linear partial differential equation by using Cramer's rule.
(W25 - Q2c, 07 marks)
(Also in S23 OR, W23 OR, S25 OR)
2. Explain Domain and boundaries for the solution of elliptic equations in two dimensions. (S23 - Q2a, 03 marks)
(Also in S22, W22, W25)
3. Explain Domain and boundaries for the solution of parabolic equations in two dimensions.
(S22 - Q1b, 04 marks)
(Also in S23, W23, S25)

Other Important Questions:

1. Differentiate between structured and unstructured grids. (W25 - Q2b, 04 marks)
 2. Explain Eigen value method for determining the classification of PDEs. (S22 - Q1b, 04 marks)
 3. What are the different types of Partial Differential Equations (PDE)? Explain the physical behavior of PDE. (W24 - Q1c, 07 marks)
 4. How do you classify boundary conditions? (W24 - Q1b, 04 marks)
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Unit 3: Fundamentals of Discretization & Finite Difference Method

Repeated Questions:

1. Differentiate between explicit and implicit approach. (S23 - Q2b, 04 marks)
(Also in W25, S22, W24, S25)
2. Using Taylor's series, derive first-order forward-difference and rearward-difference expressions for $\partial u / \partial y$. (S23 - Q2c, 07 marks)
(Also in S25)
3. Using Taylor's series, derive second order central difference for the mixed derivative expressions for $\left(\frac{\partial^2 u}{\partial x \partial y}\right)_{i,j}$. (S23 - Q3c, 07 marks)
(Also in W25, S25)
4. Explain Tridiagonal Matrix Algorithm by using one dimensional heat conduction equation. (W25 - Q3c, 07 marks)
(Also in S23 OR, S22, W23 OR)

Other Important Questions:

1. Justify: "Implicit methods are unconditionally stable". (W25 - Q3a, 03 marks)
2. Explain ordinary and partial differential equation with its physical significance. (W25 - Q3b, 04 marks)
3. List out various computational errors. Explain rounding error with examples. (W25 - Q3c, 07 marks)
4. Explain any one property of Discretization scheme. (S23 - Q3a, 03 marks)
5. Explain Lax-Wendroff technique. (S23 - Q3b, 04 marks)
6. Define Discretization. (W23 - Q2a, 03 marks)
7. Derive the expression for substantial derivative. (W23 - Q2b, 04 marks)
8. Draw a small element representing all the forces acting on it to derive a momentum equation in X direction. (W23 - Q3a, 03 marks)
9. Write a short note on error and stability. And define the stable equation. (W23 - Q3b, 04 marks)
10. Define: Truncation error, Round-off error. (W23 - Q4a, 03 marks)
11. Explain the features of TDMA method. (W24 - Q2b, 04 marks)
12. Compare upwind, central and blended difference approximations for convection-diffusion problems. (W24 - Q2c OR, 07 marks)
13. Explain the features of Crank-Nicolson scheme. (W24 - Q3b, 04 marks)
14. Using Taylor's series expansion: 1st order forward, backward and 2nd order central difference formulas. (W23 - Q3c, 07 marks)
15. Solve FVM problem for 1-D heat diffusion. (W23 - Q3c OR, 07 marks) *(Also in S22 - Q4c)*
16. Explain ADI scheme. (S22 - Q4b, 04 marks) (Also in W22, S25)
17. Explain any one properties of Discretization scheme. (S25 - Q3a, 03 marks)
18. Explain Lax-Wendroff technique. (S25 - Q3b, 04 marks)
19. Write a short note on Explicit approach. (S22 - Q4a, 03 marks)

Unit 4: Finite Volume Method for Steady Diffusion & Advection-Diffusion Problems

Repeated Questions:

1. Explain finite volume central differencing scheme. (W25 - Q4b, 04 marks)
(Also in S22 - Q2c, S23 - Q5b, W23, S25)
2. Explain finite volume method for one dimensional steady state diffusion problem. (S23 - Q3c, 07 marks)
(Also in W22, S25, W23 OR)
3. Explain inlet and outlet boundary condition. (S23 - Q4a, 03 marks)
(Also in W22, S22, W23)
4. Explain SIMPLE algorithm. (S23 - Q5c, 07 marks)
(Also in S22 - Q5c, W24 - Q2c)

Other Important Questions:

1. Differentiate between finite difference and finite element method. (W25 - Q4a, 03 marks)
2. Using Taylor's series derive second order central for the mixed derivative expressions for $\left(\frac{d^2u}{dxdy}\right)_{i,j}$. (W25 - Q4c, 07 marks)
3. Compare One and Two equation turbulence models. (W25 - Q4a OR, 03 marks)
4. Explain RANS turbulence modeling in brief. (W25 - Q4b OR, 04 marks)
5. Explain different types of grid elements. List out the factors of grid element selection. (W25 - Q4c OR, 07 marks)
6. Explain grid generation for one dimensional heat diffusion problem for finite volume method. (S23 - Q4b, 04 marks)
7. Explain the stability requirement for the solution of explicit form of one dimensional steady state heat diffusion equation. (S23 - Q4c, 07 marks)
8. Justify: Implicit methods are unconditionally stable. (S23 - Q4a OR, 03 marks)
9. Explain advantages and disadvantages of implicit approach. (S23 - Q4b OR, 04 marks)
10. Explain Tridiagonal Matrix Algorithm by using one dimensional heat conduction equation. (S23 - Q4c OR, 07 marks) *(Also in Unit 3)*
11. Explain factors affecting grid generation. (S23 - Q5a, 03 marks)
12. Explain PISO algorithm. (S23 - Q5c, 07 marks)
13. Differentiate between structured and unstructured grid. (S23 - Q5a OR, 03 marks)
14. Explain in brief: Staggered grid. (S23 - Q5b OR, 04 marks)
15. What is the purpose of domain or control volume in CFD problem? (W22 - Q4a, 03 marks)
16. Write a note on "False diffusion". (W22 - Q4b, 04 marks)
17. List out different types of error. Explain any one. (W22 - Q4c, 07 marks)
18. Why Boundary condition is required to solve the problem in CFD? (W22 - Q4a OR, 03 marks)
19. What is advection scheme? Explain. (W22 - Q4b OR, 04 marks)
20. What are the difference between First order Upwind scheme and Second order Upwind scheme? Explain in brief. (W22 - Q4c OR, 07 marks)
21. Derive an expression for 2-D steady state heat conduction equation in Cartesian coordinates by finite volume method. State the stability criteria. (W24 - Q3c, 07 marks)
22. Explain the method of solving an incompressible flow problem using stream function vorticity formulation. (W24 - Q3c OR, 07 marks)
23. Differentiate FDM, FEM and FVM. (W24 - Q4b, 04 marks) *(Also in S22, W22)*

Unit 5: Numerical Solutions of Navier-Stokes Equations

Repeated Questions:

1. Compare SIMPLE and SIMPLEC algorithm. (W25 - Q5a, 03 marks)
2. Write a note on application of CFD in automobile engineering. (W25 - Q5c, 07 marks)
3. Explain PISO algorithm. (S22 - Q4c, 07 marks) (*Also in S23, W22*)

Other Important Questions:

1. List out advantages and disadvantages of explicit approach. (W25 - Q5b, 04 marks)
 2. Why grid generation is needed in CFD? Explain it. (W25 - Q5a OR, 03 marks)
 3. Explain stretched grid. (W25 - Q5b OR, 04 marks)
 4. Write a note on requirement of grid independence study in CFD. (W25 - Q5c OR, 07 marks)
 5. Explain SIMPLE algorithm. (W22 - Q5c, 07 marks) (*Also in Unit 4*)
 6. Explain SIMPLER Algorithm, SIMPLEC Algorithm, PISO Algorithm. (Syllabus Topic)
 7. Explain Staggered grid and Collocated grid. (Syllabus Topic)
 8. Explain Discretization of the Momentum Equation, Stream Function-Vorticity approach and Primitive variable approach. (Syllabus Topic)
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Unit 6: Numerical Grid Generation

Repeated Questions:

1. Differentiate between structured and unstructured grids. (W25 - Q2b, 04 marks) *(Also in Unit 2)*
2. Explain factors affecting grid generation. (S23 - Q5a, 03 marks) *(Also in W24, S25)*
3. Explain stretched grid. (W25 - Q5b OR, 04 marks) *(Also in W23)*

Other Important Questions:

1. List out various computational errors. Explain rounding error with examples. (W25 - Q3c, 07 marks) *(Also in Unit 3)*
 2. Explain different types of grid elements. List out the factors of grid element selection. (W25 - Q4c OR, 07 marks)
 3. What is Grid? List out factor affecting of grid generation. (S22 - Q4b, 04 marks)
 4. What is Grid Transformation? Why it is required? (S22 - Q5a, 03 marks)
 5. Discuss unstructured grid. (W23 - Q4b, 04 marks)
 6. Explain steps for CFD Preprocessing and CFD Post Processing. (W23 - Q4c, 07 marks)
 7. Derive expressions to transform first derivatives w.r.t x, y & t to ξ, η & τ . (W23 - Q4c OR, 07 marks)
 8. Derive 2nd order derivative terms of Laplace equation in difference terms. (W23 - Q5b, 04 marks)
 9. Write a note on relaxation technique. (W23 - Q5b OR, 04 marks)
 10. List out different types of grid. Explain any one in short. (W22 - Q3b, 04 marks)
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Unit 7: Basics of Turbulence Modelling

Repeated Questions:

1. Explain RANS modeling in brief. (S23 - Q3a, 03 marks)
(Also in W25 - Q4b OR, S22 - Q5a, W24 - Q4a OR)
2. Compare One and Two equation turbulence models. (W25 - Q4a OR, 03 marks)
(Also in W22 - Q5a, W24 - Q5a OR)

Other Important Questions:

1. Explain RANS turbulence modeling in brief. (W25 - Q4b OR, 04 marks)
2. List out different types of Turbulence model. (W22 - Q3a, 03 marks)
3. What are the advantages and disadvantages of $\kappa - \epsilon$ model? (W24 - Q3b, 04 marks)
4. Explain Zero, One and Two equation models. (Syllabus Topic)
