INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

AERONAUTICAL ENGINEERING

TUTORIAL QUESTION BANK

Course Name	:	**COMPUTATIONALAERODYNAMICS**
Course Code	:	A62114
Class	:	III B. Tech II Semester
Branch	:	Aeronautical Engineering
Year	:	2017 – 2018
Course Coordinator	:	Dr. G Malaikhannan, Professor, Department of Aeronautical Engineering
Course Faculty	:	Mr. G Satya Dileep, Assistant Professor, Department of Aeronautical Engineering

COURSE OBJECTIVES :

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited.

In line with this, Faculty of Institute of Aeronautical Engineering, Hyderabad has taken a lead in incorporating philosophy of outcome based education in the process of problem solving and career development. So, all students of the institute should understand the depth and approach of course to be taught through this question bank, which will enhance learner’s learning process.

S No	QUESTION	Blooms taxonomy level	Course Outcomes
	UNIT – I **BASIC ASPECTS OF COMPUTATIONAL AERODYNAMICS**		
Part - A (Short Answer Questions)			
1	Define substantial derivative with example.	Understand	1
2	Define infinitesimal fluid element used in flow conditions.	Understand	1
3	State any two applications of CFD in engineering.	Remember	1
4	Define divergence of velocity in aerodynamics.	Understand	1
5	Define finite control volume for a defined flow.	Understand	1
6	Define strong conservation form of governing equations.	Understand	1
7	What is shock capturing technique in CFD?	Remember	1
8	What is shock fitting technique in CFD?	Understand	1
9	Mention the applications of CFD in industrial manufacturing.	Remember	1
10	What are different models of fluid flow?	Understand	1
Part - B (Long Answer Questions)			

1	Which three disciplines is CFD derived from? Discuss some of the advantages of using CFD	Understand	1
2	How CFD is helpful as a research tool, a design tool, and an educational tool in analyzing fluid dynamical problems	Understand	1
3	What is substantial derivative? Derive the expression for time rate of change of fluid element. Define local derivative, convective derivative	Remember	1
4	Describe the details that CFD can capture in the simulation of hydro Cyclones a process commonly used in the minerals industry?	Understand	1
5	How can CFD influence the way swimmers improve their swimming Strokes? And how CFD is useful in increasing the efficiency.	Remember	1
6	Discuss from which industry has CFD emerged from. Write some advantages and disadvantages of using CFD	Understand	1
7	Explain the physical meaning of Divergence of Velocity that frequently appears in the equations of fluid dynamics. Define substantial Derivative and explain its physical meaning.	Remember	1
8	Discuss some of the applications of CFD and explain why it is so important in the modern study of fluid mechanics?	Understand	1
9	Discuss how Computational Fluid Dynamics is vital in the following fields. a) Automobile engineering b) Industrial manufacturing. c) Civil engineering.	Remember	1
10	Describe the steps involved in Computational Fluid Dynamics (CFD) process.	Understand	1
Part - C (Problem Solving and Critical Thinking Questions)			
1	Discuss with a neat diagram shock capturing method along with its merits and demerits. Explain why conservation form of governing equations is important for calculations using shock capturing method.	Remember	2
2	Explain how the continuity equation derived from these flow models can be converted from conservative to non conservative form.	Remember	2
3	Derive momentum equation in conservation form using infinitesimal small fluid element moving with the flow.	Understand	2
4	Derive energy equation in conservation form using infinitesimal small fluid element fixed in space for compressible inviscid flow.	Remember	2
5	Explain and Differentiate shock fitting and shock capturing methods	Remember	2
6	Write short notes on non-conservative form of governing equations. Derive continuity equation in non conservation form using infinitesimal small fluid element moving in space.	Understand	2
7	Write down the most generic form of a partial differential equation used in CFD and explain the significance of each term.	Remember	2
8	Derive energy equation in conservation form using infinitesimal small fluid element moving in space for compressible viscous flow.	Understand	2
9	Derive energy equation in conservation form using infinitesimal small fluid element fixed in space in terms of internal energy for compressible flow.	Remember	2
10	Derive the energy equation in only internal energy form. And explain its significance.	Remember	2
UNIT – II **MATHEMATICAL BEHAVIOR OF PARTIAL DIFFERENTIAL EQUATIONS AND THEIR IMPACT ON COMPUTATIONAL AERODYNAMICS**			
Part – A (Short Answer Questions)			
1	Define quasi linear partial differential equations.	Understand	3
2	Define characteristic curve and its uses.	Understand	3
3	Differentiate hyperbolic, parabolic and elliptic equations	Understand	3
4	Define compatibility equation for method of characteristics.	Remember	3
5	Explain domain of dependence and range of influence	Understand	3
6	What are Parabolized Navier-Stokes equations?	Remember	3

7	Define region of influence for a fluid flow.	Remember	3
8	Explain Domain of dependence for a fluid flow.	Remember	3
9	Explain well-posed problems with example for numerical analysis.	Understand	3
10	When an equation is called Parabolized Navier-Stokes equation.	Remember	3
Part - B (Long Answer Questions)			
1	What is a quasi linear system?	Understand	3
2	What is a Cramer's rule?	Understand	3
3	What is Eigen value method?	Understand	3
4	Define characteristic curve and its uses.	Remember	3
5	Write the constraints for Hyperbolic, Parabolic & elliptical equations.	Understand	3
6	What is a region of influence and its importance in CFD?	Remember	3
7	What is domain of dependence and its importance in CFD?	Remember	3
8	Which are the equations called Boundary Layer Equations?	Remember	3
9	How will be the mathematical behaviour of various types of partial differential Equations?	Understand	3
10	State whether second order wave equation is a hyperbolic equation?	Understand	3
Part – C (Problem Solving and Critical Thinking)			
1	Classify the following set of equations for irrotational, two-dimensional, in viscid, steady flow of a compressible flow using Eigen value method: $$(1-M_\infty^2)\frac{\partial u'}{\partial x}+\frac{\partial v^1}{\partial y}=0$$ $$\frac{\partial u'}{\partial y}-\frac{\partial v'}{\partial x}=0$$ Where u', v' are small perturbation velocities measured relative to the free Stream velocity.	Understand	5
2	Explain the classification of the following quasi-linear partial differential equations using Cramer's rule: $a_1(\partial u/\partial x) + b_1(\partial u/\partial y) + c_1 (\partial v/\partial x) + d_1 (\partial v/\partial y) = f_1$ $a_2(\partial u/\partial x) + b_2 (\partial u/\partial y) + c_2 (\partial v/\partial x) + d_2 (\partial v/\partial y) = f_2$ Where u and v are dependent variables, continuous functions of x and y and a_1, a_2, b_1, b_2, c_1, c_2, d_1, d_2, f_1, f_2 can be functions of x, y, u and v.	Understand	4
3	Discuss the physical behaviour of flows governed by hyperbolic equations with an example of steady, in viscid supersonic flow over a two dimensional circular arc airfoil.	Remember	4
4	Discuss the physical behaviour of flows governed by parabolic equations with an example of steady boundary layer flows. Explain PNS model for high speed flows and explain its merits.	Understand	4
5	Classify the following partial differential equations according to their nature as elliptic, parabolic, hyperbolic (a) Unsteady Thermal Conduction Equation (b) Laplace's Equation (c) Second-order wave equation (d) First - order wave equation	Remember	4
6	Write short notes on the following: (a) Parabolized Navier-Stokes equations (b) Well-posed problems.	Understand	5
7	Discuss the mathematical and physical behaviour of flows governed by Parabolic equations with an example of unsteady thermal conduction in two and three dimensions.	Understand	4
8	Explain the mathematical and physical nature of flows governed by parabolic Equations with an illustration of a steady boundary layer flow.	Remember	5

9	Discuss the mathematical and physical nature of flows governed by elliptic equations with an illustration of incompressible, inviscid flow. Explain Neumann and Dirichlet boundary conditions.	Understand	5
10	What are characteristic lines? Explain the philosophy of the Method of characteristics. Consider the full velocity potential equation for the steady, two dimensional supersonic flow and determine the equation for characteristic curves in the physical xy space and classify the nature of velocity potential equation based on Mach number.	Understand	4
UNIT-III **BASIC ASPECTS OF DISCRETIZATION**			
Part - A (Short Answer Questions)			
1	What are the errors that influence numerical solutions the PDE.	Understand	6
2	How to reduce the truncation error in numerical calculations?	Understand	6
3	Write advantages of explicit approach.	Remember	6
4	Write disadvantages of the explicit approach.	Understand	6
5	Write advantages of implicit approach.	Understand	7
6	Define Courant number. What is the important stability criterion for hyperbolic equation?	Remember	6
7	Define discretization error in numerical approach.	Understand	6
8	Define Round-off error and its effects.	Remember	6
9	Write disadvantages of the implicit approach.	Understand	7
10	Define the need of grid point in discretization.	Remember	6
11	Write the governing equation of steady diffusion	Understand	6
12	Define method of finite differences.	Understand	6
13	Discuss about truncation error in numerical approach.	Understand	6
14	Define first order forward difference with example.	Understand	7
15	Explain first order accurate with example.	Remember	7
16	Define rearward difference in discretization.	Understand	6
17	Define explicit approach.	Remember	10
18	What are finite difference modules?	Understand	6
19	Define difference equations with an example.	Understand	7
20	Explain the need of second order accuracy in finite difference equations.	Understand	10
21	Define second order accurate equations with example.	Understand	6
22	Explain second order central difference equation with example.	Remember	6
23	Define second order central second difference equation with example.	Understand	7
24	Define second order central second difference for mixed derivative equation with example.	Remember	6
25	Write two differences between structured and unstructured grids?	Understand	8
26	Draw triangular and Tetrahedral cells.	Understand	8
27	State the need of hybrid grids	Remember	7
28	Define compressed grids and its need.	Understand	8
29	State Cartesian grids.	Remember	8

30	What is body fitted structured grid.	Understand	9
31	Define Adaptive Grids	Understand	8
32	Write the advantages of adaptive grid	Remember	8
33	What are the topologies used in grid generation	Understand	8
34	Define Unstructured Grids	Understand	11
35	Define grid.	Understand	11
36	Draw the H - O - H mesh?.	Remember	11
37	Define structured grid.	Understand	11
38	Define need of unstructured grid.	Remember	11
39	State hybrid grid.	Understand	11
40	State Multi-block grids.	Understand	11
41	State need for grid generation.	Remember	11
42	Draw the Cartesian grid.	Understand	11
43	Draw the C mesh.	Remember	11
44	State types of grid used in CFD techniques.	Understand	11
45	Draw the I- mesh ?	Understand	11
46	Draw the H- mesh?	Remember	11
47	Draw the O- mesh?	Understand	11
48	Define mixed element grids	Remember	8
Part – B (Long Answer Questions)			
1	Discuss the main advantages and disadvantages of discretization of the governing equations through the finite difference method	Remember	9
2	Explain Lax method for one dimensional wave equation and explain the stability criterion for hyperbolic equations	Understand	8
3	Explain the explicit formulation by using one dimensional heat conduction equation as an example with its relative merits and demerits	Understand	9
4	Write the advantages & disadvantages of implicit method and its applications in CFD techniques.	Understand	8
5	Write the advantages & disadvantages of explicit method and its applications in CFD techniques.	Understand	9
6	What is H - O - H mesh? Explain it with neat sketch and its applications.	Remember	11
7	What are tri angular and Tetrahedral cells?	Understand	11
8	What are Hybrid Grids? Explain with neat sketch.	Understand	11
9	Explain the applications of Quadrilateral Cells in grid generation?	Remember	11
10	What are Hexahedra cells? Explain with its area of applications.	Understand	11
Part – C (Problem Solving and Critical Thinking)			
1	Write short notes on the following properties of numerical solutions of fluid flows: i) Stability ii) Consistency iii) Accuracy iv) Convergence.	Remember	8
2	a) Explain the implicit formulation with an example. b) What is the use of Thomas algorithm?	Understand	8
3	Explain Von Newmann stability analysis with an example.	Remember	9
4	Write down the formulation of central difference scheme for u velocity in the x direction. What is the truncation error in terms of Δx and state the order of this discretization scheme?	Understand	9

5	a) What are the errors that occur in computational aero-dynamics? b) Compare and contrast explicit and implicit formation methods.	Remember	10
6	Explain the importance of grid generation in CFD process and discuss the difference between structured grid and unstructured grid	Understand	11
7	Explain O, H, C grid topologies with sketches along with their applications	Understand	11
8	Define structured and unstructured grids. Discuss various configurations of Body-fitted structured grids and multi-block grids with the help of sketches.	Remember	11
9	Write short notes on adaptive grids and overset grids	Understand	11
10	Explain C-H, H-O-H, O-H grid topologies with sketches along with their applications	Understand	11
UNIT-IV **FINITE VOLUME METHODS**			
Part - A (Short Answer Questions)			
1	Define finite element method	Remember	12
2	Write the essential characteristics of FEM in CFD?	Understand	12
3	What is the basis of Finite Volume Method?	Remember	12
4	Define cell in finite volume method.	Understand	12
5	Define node in finite volume method.	Understand	12
6	Define cell-centers, cell-vertices in Finite Volume Method.	Remember	12
7	Define staggered grid approach.	Understand	12
8	Define two dimensional finite volume methods.	Remember	12
9	What is numerical scheme for Finite Volume Method analysis?	Understand	12
10	Define one condition for finite volume selection.	Remember	12
Part – B (Long Answer Questions)			
1	What is a Finite Volume Method? Explain the importance of FVM in CFD	Understand	12
2	Explain cell centred approach in Finite Volume Method?	Understand	12
3	What is a cell vertex approach in Finite Volume Method?	Understand	12
4	What is Finite Volume Discretization?	Understand	12
5	What is a grid point and its applications?	Understand	12
6	Write the steps involved in Finite Volume Method.	Remember	12
7	How Finite Volume Method is different from Finite Difference Method & Finite Element Method?	Understand	12
8	What are the advantages of Finite Volume Method?	Remember	12
9	What is a cell averaged method? Explain it with an example.	Understand	12
10	Give an example solving for FVM (1-D Problem).	Remember	12
Part – C (Problem Solving and Critical Thinking)			
1	Explain cell-centered and cell-vertex discretization methodologies used in Finite volume approach with the help of sketches. What are the constraints to be satisfied on the choice of discretized control volumes for a consistent finite volume method?	Remember	12
2	Explain the reasons that make finite volume method superior to other Discretization methods in CFD. Discuss the cell-centered and cell-vertex approaches to finite volume discretization using sketches	Understand	12

3	Define finite volume discretization and explain the features which distinguish the interpretation of finite volume methods from the finite difference approach	Remember	12
4	Discuss the general formulation of a numerical scheme based on finite volume method	Understand	12
5	Explain the two-dimensional finite volume method and describe evaluation of fluxes through cell surfaces using central discretization schemes	Understand	12
6	State the difference between cell-centred and cell-vortex methods.	Remember	12
7	State the difference between finite volume method and finite element method.	Understand	12
8	Derive the formulation for numerical scheme in discretization.	Understand	12
9	State the conditions on the finite volume selections	Remember	12
10	Explain one example for two dimensional Finite Volume Methods.	Understand	12
UNIT-V **CFD TECHNIQUES**			
Part - A (Short Answer Questions)			
1	Describe briefly Lax-Wendroff technique	Understand	13
2	Describe briefly MacCormack's technique-	Remember	13
3	What is Relaxation technique?	Understand	14
4	Write about numerical dissipation and dispersion	Understand	13
5	Describe briefly Alternating-Direction-Implicit (ADI) Technique	Remember	14
6	Describe briefly Crank Nicholson technique	Understand	15
7	What is Pressure correction technique?	Understand	16
8	Write three applications to incompressible viscous flow?	Remember	15
9	What is the need for staggered grid?	Understand	15
10	What is Lax-Wendroff time-stepping?	Remember	15
Part – B (Long Answer Questions)			
1	Describe the process of Lax-Wendroff technique?	Understand	14
2	Explain briefly MacCormack's technique and its applications?	Understand	14
3	What is a Crank Nicholson technique? Explain its advantages in field of CFD techniques.	Remember	14
4	What is the Relaxation technique? Explain its applications.	Remember	15
5	What are the aspects of Numerical Dissipation?	Remember	15
6	Explain the process of Alternating Direction Implicit Technique?	Understand	13
7	What is a pressure correction formula?	Remember	15
8	Derive central difference formulation of Poison's equation?	Understand	15
9	Define Numerical Dissipation.	Understand	14
10	What is a point iterative method in numerical analysis?	Understand	13
Part – C (Problem Solving and Critical Thinking)			
1	Explain explicit MacCormack Technique for a steady, two-dimensional, supersonic, in viscid flow field in (x,y) space using the following generic conservation form without source terms: $\partial F/\partial x = - \partial G/\partial y$ where F and G represent flux vectors formed from the governing equations.	Understand	15
2	Discuss MacCormack explicit predictor-corrector method using an example	Remember	15
3	Explain Crank-Nicolson implicit scheme used for solving the parabolic partial differential equations	Understand	15

4	Explain explicit Lax-Wendroff technique for an unsteady, two-dimensional, inviscid flow	Remember	14
5	Describe a relaxation method for solving the elliptical partial differential equations	Understand	15
6	Discuss ADI method for solving parabolic problems	Remember	14
7	List out the advantages and disadvantages of explicit and implicit methods	Remember	15
8	Discuss numerical dissipation and numerical dispersion in the context of numerical solution to fluid dynamical problems	Understand	14
9	Explain checker-board behaviour of velocity and pressure fields in central discretization schemes using sketches and explain how such behaviour can be avoided	Remember	15
10	Describe the SIMPLE algorithm step by step for estimation of velocity and Pressure fields in solving incompressible viscous flow problems.	Remember	16

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