MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent institution of MAHE, Manipal)

V SEMESTER B. TECH (AERONAUTICAL ENGINEERING)
END-SEMESTER EXAMINATION, DEC., 2021
COURSE: COMPUTATIONAL FLUID DYNAMICS (AAE 4075)

PART-A

REVISED CREDIT SYSTEM

Duration: 50 Mins **Date: 27/12/2021** **MAX. MARKS: 30**

Note: All questions are compulsory and each question carry 1 mark.

Q1.	Choose the correct statement 1. The non-conservation form of governing equations can be obtained by using integral approach 2. The non-conservation form of governing equations can be obtained by using differential approach 3. The non-conservation form of governing equations can be obtained either by using integral approach or differential approach 4. None of above
Q2.	In ____ approach, the region under study is large in size. 1. Finite control volume 2. Infinitesimal fluid element 3. molecular 4. all above
Q3.	For steady subsonic flow over a wing model, which of the following physical principle(s) will be applicable? 1. Continuity equation and energy equation 2. Continuity equation and momentum equation 3. Only the continuity equation 4. Continuity equation, momentum equation and energy equation
Q4.	Uniform flow of air takes place over a flat plate with velocity, $V = 5x^2ti$. Velocity along the x-direction is 3 m/s. The total acceleration at x = 2 m and t = 5s is _____ m/s^2. 1. 42 2. 320 3.12 4. 20
Q5.	For supersonic flow, the following partial differential equation will be _____ in nature.

	$$(1 - M_\infty^2)\frac{\partial^2 \emptyset}{\partial x^2} + \frac{\partial^2 \emptyset}{\partial y^2} = 0$$ 1. Hyperbolic 2. elliptic 3. parabolic 4. quadratic
Q6.	Choose the wrong statement. 1. Elliptic equation requires boundary conditions over the entire domain. 2. Elliptic equations can be solved by using marching technique 3. The governing equations for steady supersonic inviscid flows follow hyperbolic nature 4. The governing equations for unsteady heat transfer by conduction through a metallic plate follows parabolic nature.
Q7.	$T + \frac{dT}{dx}$ is _____ boundary condition 1. Neumann 2. Dirichlet 3. combination of Neumann and Dirichlet 4. adiabatic wall
Q8.	Consider the initial boundary value problem $$\frac{\partial u}{\partial t} = \alpha \frac{\partial^2 u}{\partial x^2}$$ where, u is non-dimensional temperature, α is constant and t > 0. The initial conditions are u(x,0) = e^{x^2} for 0 < x < 1 and boundary conditions are u(0, t) = 1, u(1, t) = 2.718 for all time, t ≥ 0 Use, $r = \frac{\alpha t}{(\Delta x)^2} = 1\ and\ \Delta x = 1/4$ The non-dimensional temperature at zero time level and second-last grid is _____ 1. 1.659 2. 3.343 3. 2. 785 4. 1.755
Q9.	Consider the initial boundary value problem $$\frac{\partial u}{\partial t} = \alpha \frac{\partial^2 u}{\partial x^2}$$ where, u is non-dimensional temperature, α is constant and t > 0. The initial conditions are u(x,0) = e^{x^2} for 0 < x < 1 and

	boundary conditions are u(0, t) = 1, u(1, t) = 2.718 for all time, t ≥ 0 Use, $r = \frac{\alpha t}{(\Delta x)^2} = 1\ and\ \Delta x = 1/4$ The non-dimensional temperature at first time level and second grid is ______ 1. 1.6 2. 1.2 3. 2.1 4. 2.4
Q10.	Consider the initial boundary value problem $$\frac{\partial u}{\partial t} = \alpha \frac{\partial^2 u}{\partial x^2}$$ where, u is non-dimensional temperature, α is constant and t > 0. The initial conditions are u(x,0) = e^{x^2} for 0 < x < 1 and boundary conditions are u(0, t) = 1, u(1, t) = 2.718 for all time, t ≥ 0 Use, $r = \frac{\alpha t}{(\Delta x)^2} = 1\ and\ \Delta x = 1/4$ The non-dimensional temperature at first time level and third grid is ______ 1. 1.519 2. 2.846 3. 1.935 4. 2.694
Q11.	Consider the initial boundary value problem $$\frac{\partial u}{\partial t} = \alpha \frac{\partial^2 u}{\partial x^2}$$ where, u is non-dimensional temperature, α is constant and t > 0. The initial conditions are u(x,0) = e^{x^2} for 0 < x < 1 and boundary conditions are u(0, t) = 1, u(1, t) = 2.718 for all time, t ≥ 0 Use, $r = \frac{\alpha t}{(\Delta x)^2} = 1\ and\ \Delta x = 1/4$ The non-dimensional temperature at first time level and fourth grid is ______ 1. 5.264 2. 2.675 3. 4.378 4. 2.059
Q12.	Alternating-Direction-Implicit method is useful to solve problems based on _____ 1. steady one dimensional heat conduction 2. steady two dimensional heat conduction

	3. unsteady two dimensional heat conduction 4. unsteady one dimensional heat conduction
Q13.	The computation time per time step for implicit scheme is ______ the explicit scheme. 1. smaller than 2. higher than 3. same as 4. none of above
Q14.	Thomas algorithm is preferred for solving large size matrices because _______ 1. it gives accurate solution 2. it reduces the required number of manipulations 3. programming is easy 4. none of above
Q15.	Following equation is ______ in nature. $$x^3 + 2xy + 5x^2y^3 = 8$$ 1. Implicit 2. explicit 3. quadratic 4. none of above
Q16.	One-dimensional steady state heat conduction takes place through a wall of thermal conductivity 70 W/m^{o}C. Consider three nodes along the width of the wall with equal spacing of 0.1 m. The temperature at the extreme left node is maintained at 80^{o}C, whereas, extreme right node is subjected to a heat flux of 3500 W/m^2. The temperature at the second node is ___^{o}C. 1. 88 2. 85 3. 90 4. 93
Q17.	One-dimensional steady state heat conduction takes place through a wall of thermal conductivity 70 W/m^{o}C. Consider three nodes along the width of the wall with equal spacing of 0.1 m. The temperature at the extreme left node is maintained at 80^{o}C, whereas, extreme right node is subjected to a heat flux of 3500 W/m^2. The temperature at the extreme right node is ___^{o}C. 1. 96 2. 100 3. 90 4. 104
Q18.	______ is an example of elliptic equation 1. unsteady and subsonic flow 2. unsteady and compressible flow 3. steady and subsonic flow

	4. steady and supersonic flow
Q19.	If the value of Cell Peclet number is greater than ± 5, CDS method does not satisfy the ________ property of discretization schemes a) Conservativeness b) Boundedness c) Transportiveness d) Truncation error
Q20.	Cell Peclet Number (Pe), in the case of Pure Diffusion is _______ a) Infinity b) Equal to Zero c) More than +2 d) Less than –2
Q21.	‘Checker board pressure field’ can be solved using _______ a) Course grid b) Fine grid c) Collocated grid d) Staggered grid
Q22.	Order of Truncation error in the case of UDS method is ______ a) Zero Order b) First order c) Second order d) Third order
Q23.	QUICK method uses (case Fe > 0, Fw > 0) ______ a) Two bracketing nodes and one upstream node b) Two bracketing nodes and one downstream node c) Two upstream nodes and two downstream nodes d) None of the above
Q24.	In case of boundary control volumes, S_p is ______ a) Always equal to Zero b) Always more than Zero c) Always Less than Zero d) None of the above
Q25.	In case of UDS method when u_e< 0, u_w< 0 flow variable Ø at the face is evaluated as _____ a) $\emptyset_e = \emptyset_P$ and $\emptyset_w = \emptyset_E$ b) $\emptyset_e = \emptyset_E$ and $\emptyset_w = \emptyset_P$ c) $\emptyset_e = \emptyset_W$ and $\emptyset_w = \emptyset_E$ d) $\emptyset_e = \emptyset_W$ and $\emptyset_w = \emptyset_E$

Q26.	In case of SIMPLE algorithm, _____ a) Only pressure correction equation has to be under relaxed b) Only velocity correction equation over relaxed c) Both pressure and velocity correction equation has to be over relaxed d) Both pressure and velocity correction equation has to be under relaxed
Q27.	In case of SIMPLE algorithm, for a converged solution _____ a) Pressure correction will be zero b) Velocity correction will be zero c) Both pressure and velocity corrections will be zero d) Both pressure and velocity corrections will not be zero
Q28.	Continuity equation is represented as _____ a) $F_e - F_w = 0$ b) $D_e - D_w = 0$ c) $D_e - F_w = 0$ d) $D_w - F_e = 0$
Q29.	Error due to Numerical False diffusion in case of UDS method _____ a) Increases with finer grid b) Decreases with courser grid c) Decreases with finer grid d) Reduces to zero with finer grid
Q30.	_________ method is conditionally stable under certain modest value of Peclet number (e.g Pe = 8/3) a) CDS b) UDS c) QUICK d) None of the above

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PART-B

REVISED CREDIT SYSTEM

Duration: 75 Mins (+10 Mins uploading Time) **Date: 27/12/2021** **MAX. MARKS: 20**

Note:

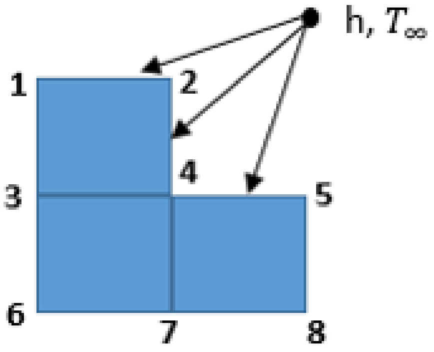
- *All questions are compulsory*
- *Draw a neat diagram wherever necessary*
- *Stepwise answers carry marks*

Q1. A slab is subjected to the combined effect of convection and heat flux at it's left face. Considering internal heat generation within the slab, write the energy balance equation for the extreme left node and it's adjacent node. **[2M]**

Q2. Discretize the following equation using the forward difference method and obtain the general form of it. Consider equal grid spacing of 0.1 along the x and y directions. **[3M]**

$$5\frac{\partial^2 u}{\partial x^2} + 3\frac{\partial^2 u}{\partial y^2} + 7\frac{\partial u}{\partial x} + \frac{\partial u}{\partial y} + 4 = 0$$

Q3. Consider a L-shaped metallic block of thermal conductivity, 10 W/m^{o}C as shown in the following figure. The temperature at nodes 6, 7 and 8 is same as 100^{o}C and at nodes 4 and 5 it is 70^{o}C and 50^{o}C, respectively. The left face of the block (i.e. nodes 1, 3 and 6) is insulated. The faces 1-2, 2-4 and 4-5 are subjected to a heat transfer coefficient of 125 W/m^{o}C at ambient temperature, T_∞ of 30^{o}C. There is an internal heat generation of 20,000 W/m^3 within the block. Considering an equal grid spacing of 2 cm along x and y directions, determine the temperature at nodes, 1, 2 and 3. **[5M]**



Q4. Explain four Basic Rules of Control Volume formulation. **[2M]**

Q5. With a suitable example explain Numerical False Diffusion. **[3M]**

Q6. **[5M]**

A property ϕ is transported by means of convection and diffusion through the one dimensional domain sketched below. The governing equation is

$$\frac{d}{dx}(\rho u \phi) = \frac{d}{dx}\left(\Gamma \frac{d\phi}{dx}\right)$$

The boundary conditions are $\phi_0 = 1.2$ at x = 0 and $\phi_L = 0$ at x = L. Using five equally spaced cells and the UDS calculate the distribution of ϕ when u = 0.2 m/s. Consider L = 0.5m, Γ = 0.1 and $\rho = 1.5$,