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P.E.S. College of Engineering, Mandya - 571 401

(An Autonomous Institution affiliated to VTU, Belagavi)

Eighth Semester, B.E. - Mechanical Engineering

Semester End Examination; June - 2017

Computational Fluid Dynamics

Time: 3 hrs *Max. Marks: 100*

***Note**: i) Answer **FIVE** full questions, selecting **ONE** full question from each unit.*
ii) Missing data, if any, may be suitably assumed.

UNIT - I

1	a.	State the advantages and disadvantages of solving problems using CFD approach when compare to experimental and theoretical approach.	6
	b.	Conservative form of continuity equation is given by : $\frac{\partial}{\partial t}\iiint \rho dV + \iint \rho V.ds = 0$, Show that the same can be written in equivalent conservation form as $\frac{\partial \rho}{\partial t} + \nabla.(\rho V) = 0$.	8
	c.	Write down the Navier Stokes equation (Continuity, Momentum and Energy equations) for unsteady flow of viscous compressible fluid in non conservation form.	6
2	a.	List and explain the steps of CFD analyses.	6
	b.	Develop the momentum equation in three dimensions for viscous flow, in Cartesian Coordinate system.	8
	c.	Computational fluid dynamics is a 'research tool' to carry out numerical experiment, discuss this statement with suitable example.	6

UNIT - II

3	a.	Explain the classification of physical behavior of partial differential equations.	6
	b.	Consider in an inviscid flows ,we analyze the potential equation which governs 2d, steady, isentropic, compressible flow past a slender body with a free stream Mach number M_∞ $\left(1-M_\infty^2\right)\frac{\partial^2\phi}{\partial x^2}+\frac{\partial^2\phi}{\partial y^2}=0$ Based on the Eigen value method state the nature of partial differential equations	8
	c.	Explain with examples, the difference between Neuman boundary conditions, direichlet boundary conditions and mixed boundary conditions	6
4	a.	What is characteristic lines and explain the physical significance of this on the solution of parabolic Partial differential equations?	8

Contd….2

b. Classify mathematically the following PDE : 6

i) $\partial^2\phi/\partial x^2 + \partial^2\phi/\partial y^2 = 0$ ii) $\partial u/\partial t + c\partial u/\partial x = 0$

c. What do you mean by Well-Posed Problems? Explain. 6

UNIT - III

5 a. A fluid has as absolute viscosity of 0.048 Pa-s. For the flow of such a fluid over a flat solid surface the velocity at a point 75mm away from the surface is 1.125 m/s. assume a parabolic velocity distribution ($U = a+by+cy^2$), with the vertex at 75 mm away from the surface where velocity is 1.125 m/s Imagine that the discrete value of U are obtained at discrete grid points located at 25 mm, 50 mm, and 75 mm away from boundary surface. Using these discrete values calculate the shear stress at solid boundary surface by three different ways, 8

i) Using first order one sided difference

ii) Using second order one sided difference

iii) Compare this with exact value.

b. Define Discretization error and Round off error and explain How to reduce the truncation error? 6

c. Develop the nodal equation of node (i, j) under steady – state conditions for the convection at corner section. 6

6 a. What are explicit, implicit and crank Nicolson schemes with respect to unsteady conduction? Derive the stability criterion for the explicit scheme for one dimensional unsteady conduction without heat generation. 10

b. Consider a large plate of thickness L = 4cm and thermal conductivity 28 W/mºC in which heat is generated uniformly at a rate of $5x10^6$ W/m^3. The left side of the plate is maintained at 0ºC by iced water while the right side is subjected to convection to an environment at 30ºC with heat transfer coefficients 45 W/m^{2}ºC. Consider five equally spaced with a nodal spacing of 1 cm. Calculate the nodal temperatures under steady conduction using Finite difference method. 10

UNIT - IV

7 a. For three noded cluster, discretize the following one dimensional steady state conduction equation using finite volume method. 10

$\frac{d}{dx}\left(k\frac{dT}{dx}\right) + s = 0$ with $S = S_u + S_p T_p$ is a piecewise linearization for $\frac{dT}{dx}$ and T_p in the source term in stepwise.

Contd….3

b. Consider source free heat conduction in an insulated rod of length 0.5 m whose ends are maintained at constant temepratures of 100ºC and 500ºC respectively. The one dimensional governed by $\frac{d}{dx}\left(k\frac{dT}{dx}\right)=0$. Calculate the steady state temperature distribution in the rod using five volume elements given that thermal conductivity k = 1000 W/mK and cross sectional area A = $10x10^{-3}m^2$ 10

8 a. Discuss the benefits of Finite volume method over Finite difference method. 5

b. Cylindrical fin with uniform cross section area A. The base is at a temperature of 100ºC and the end is insulated. The fin is exposed to an ambient temperature of 20ºC. One dimensional heat transfer in this situation is governed by $\frac{d}{dx}\left(KA\frac{dT}{dx}\right)-hp\left(T-T_\infty\right)=0$ where 'h' is the convective heat transfer coefficient; P is the perimeter, K the thermal conductivity of the material Calculate the temperature distribution along the fin. Given $\frac{hp}{KA}=25\,m^{-2}$. L is the length of the fin (L = 0.6m) the domain is divided into 3 control volumes. 15

UNIT - V

9 a. Discretize the following one dimensional convenction – diffusion equation using finite volume method $\frac{d}{dx}(\rho u\phi)=\frac{d}{dx}\left(\Gamma\frac{d\phi}{dx}\right)$ and obtain the neighboring coefficients by Upwind difference scheme. 14

b. Discuss the conservativeness property of discretisation scheme. 6

10 a. Write the governing equation for source – free one dimensional convection and diffusion of a scalar φ. Discretize this equation on a control volume enclosing node P. using central differencing and obtain a relation between φ_p, φ_w and φ_e where 'w' and 'e' are neighboring nodes. 10

b. A property is transported by means of convection and diffusion through the one dimensional domain the boundary conditions are $\varphi_0 = 1$ at $x = 0$ and $\varphi_L = 0$ at $x = L$. Using five equally spaced cells and central differencing scheme for convection and diffusion calculate the distribution of φ as a function of x for U = 2.5 m/s. 10

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