Reg. No. :

Question Paper Code : 41369

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2018
Seventh/Eighth/Tenth Semester
Mechanical Engineering
ME 6014 – COMPUTATIONAL FLUID DYNAMICS
(Common to Mechanical Engineering (Sandwich)/Aeronautical Engineering/
Manufacturing Engineering/Mechanical and Automation Engineering)
(Regulations 2013)

Time : Three Hours Maximum : 100 Marks

State clearly any assumption made wtih justification

Answer ALL questions

PART – A (10×2=20 Marks)

1. What is the need of CFD analysis for engineering problems ?

2. How many initial and boundary conditions needed for the below equation ?

$$\frac{\partial T}{\partial t} = \frac{\partial^2 T}{\partial x} + \frac{\partial^2 T}{\partial y}.$$

3. How do you check the accuracy of a numerical solution ?

4. Write the advantages and disadvantages of Euler's method.

5. For a given convection-diffusion problem, air flows with a velocity of 2 m/s and assume the diffusion conductance is 0.8. Suggest the suitable scheme to solve this problem.

6. Write down the governing equations that are applicable for 1-D convection-diffusion problem. Assume no source term.

7. What is PISO algorithm ?

8. What is the drawback of analysis of incompressible fluid flow problems by numerically ?

9. The mean of fluctuating component velocity is zero in turbulent flow – Prove it.

10. Distinguish wall turbulence and free turbulence.

PART – B (5×16=80 Marks)

11. a) By setting the first law of Thermodynamics for a fluid particle, derive the below energy equation

$$\rho\frac{DE}{Dt} = -\mathrm{div}(pu) + \left[\frac{\partial(u\tau_{xx})}{\partial x} + \frac{\partial(u\tau_{yx})}{\partial y} + \frac{\partial(u\tau_{zx})}{\partial z} + \frac{\partial(v\tau_{xy})}{\partial x} + \frac{\partial(v\tau_{yy})}{\partial y} + \frac{\partial(v\tau_{zy})}{\partial z} + \frac{\partial(w\tau_{xz})}{\partial x} + \frac{\partial(w\tau_{yz})}{\partial y} + \frac{\partial(u\tau_{zz})}{\partial z}\right]$$

$$+ \mathrm{div}(k\ \mathrm{grad}\ T) + S_E.$$

(OR)

b) i) With suitable examples, discuss the classification of partial differential equations. (10)

ii) Briefly explain how the mesh size influence the numerical errors. (6)

12. a) Derive the finite difference expressions for a first order derivative with forward, backward and central difference approximations using Taylor series expansion.

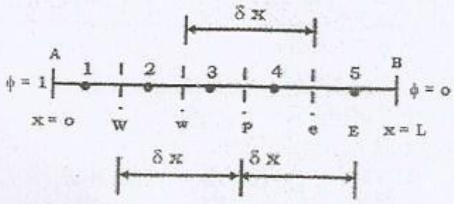
(OR)

b) A thin plate is initially at a uniform temperature of 200°C. At a certain time t = 0, the temperature of the east side of the plate is suddenly reduced to 0°C. The other surface is insulated. Use the explicit finite volume method in conjugate with a suitable time step size, calculate the transient temperature of the plate at time t = 40 sec. Consider plate thickness L = 2 cm, K = 10W/m-k, $\rho c = 10\times10^6$ J/m³/K. Consider five equal sub volume.

13. a) With suitable examples, explain the four basic rules of control volume formulation.

(OR)

b) A property φ is transported by means of convection and diffusion through the 1D sketched below.



Using five equally spaced cells and the hybrid scheme for convection and diffusion, calculate the distribution of ϕ as a function of x for u = 2.5 m/s. Take the following data : length L = 100 cm, $\rho = 1.0\ kg/m^3, \Gamma = 0.1\ kg/m/s$.

14. a) Derive the equation for convective mass flux (F) and the diffusive conductance at v-control volume using staggered grid.

(OR)

b) In SIMPLE method, discuss in detail about how to discretize the momentum equation by using guessed pressure field.

15. a) What is the need of turbulence modelling ? Brief about turbulence k-ε model with merits and demerits.

(OR)

b) i) With valid reasons, discuss the characteristics of turbulent flow. (10)

ii) For solving engineering problems, discuss the orderly steps followed in CFD software tools. (6)