BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: B. Tech. **SEMESTER : V**
BRANCH: PROD. **SESSION : MO/2022**

SUBJECT: ME353 COMPUTATIONAL FLUID DYNAMICS

TIME: 3:00 Hours **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

Q.1(a) What are the governing equations solved in computational fluid dynamics? Write down some numerical methods to solve those equations. [5]

Q.1(b) Derive the y-momentum equation [5]

$$\rho\frac{Dv}{Dt} = \frac{-\partial p}{\partial y}+\frac{\partial \tau_{xy}}{\partial x}+\frac{\partial \tau_{yy}}{\partial y}+\frac{\partial \tau_{zy}}{\partial z}+\rho f_y$$

Q.2(a) Define and give examples of elliptic, parabolic and hyperbolic partial differential equations. [5]

Q.2(b) Classify the following system of partial differential equations: [5]
a ∂u/∂x + c ∂v/∂y = f1
b ∂v/∂x + d ∂u/∂y = f2
Consider the case where a=b=1, c = -d = -1, f1=f2=0.

Q.3(a) Derive a first-order backward finite difference approximation for the mixed partial derivative [5] $\frac{\partial^2 f}{\partial x \partial y}$.

Q.3(b) Use the second-order accurate central difference approximation and the first order forward difference approximation to evaluate ∂f/∂x at x=1 for the function f(x)=e^x. Step size Δx=0.1 is to be employed. Compare the numerical results with exact value. [5]

Q.4(a) What do you understand about the consistency of a numerical scheme? Explain with an example. [5]

Q.4(b) Explain the solution procedure of the equation $\frac{\partial T}{\partial t} = c\frac{\partial^2 T}{\partial x^2}$ using an implicit scheme, where c is a constant. [5]

Q.5(a) Define and discuss on the terms stability and convergence. [5]

Q.5(b) Finite differencing of linear convection equation ∂u/∂t + c ∂u/∂x = 0 (c>0) is given by [5]
$\frac{u_j^{n+1}-u_j^n}{\Delta t}=\frac{-c}{\Delta x}\left(u_j^n-u_{j-1}^n\right)$. Obtain the modified partial differential equation of the above scheme.

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