Reg. No.



MANIPAL INSTITUTE OF TECHNOLOGY

(A constituent unit of MAHE, Manipal)

SECOND SEMESTER M.TECH. (APPLIED CFD)

END SEMESTER EXAMINATIONS, APRIL/MAY 2024

TURBULENCE, MODELING AND SIMULATION [AAE 5218]

REVISED CREDIT SYSTEM

Time: 3 Hours			Date: 3	Date: 30 April 2024			Max. Marks: 50		
Instructions to Candidates: ◆ Answer ALL the questions. ◆ Missing data may be suitably assumed.									
Q.NO 1A.	Questions For transport equations of turbulent kinetic energy, if the data for time-series of four-time instants of turbulent fluctuating velocities with the values v_1' and v_2' are given as:					Marks (05)	CO CO3	BTL L04	
	$\frac{v_1'}{v_2'}$ Differentiat	0.25 0.14	-0.35 -0.25	$ \begin{array}{c} 0.15 \\ 0.04 \\ \overline{v_{1'}{}^{2}} \\ and \\ \overline{v_{1}{}'{}^{7}} \end{array} $	-0.07 0.02				
1B.	Explain the Kolmogorov scales? Use dimensional analysis to show the expression for the velocity scale, v_{η} , the length scale, l_{η} and the time scale, τ_{η} .					(03)	C01	L05	
1C.	Explain the Boussinesq approximation?					(02)	CO1	L05	
2A.	Consider the energy spectrum as shown in figure 1.					(05)	CO1	L05	
	 a. Show the three different regions (the large energy containing scales, the -5/3 range and the dissipating scales). b. Explain each region in brief and its significance, cut-off locations? 								

c. Show, which of the two regions are isotropic?



3A. Consider the $k - \varepsilon$ model. The modeled k equation, in **(05) CO4 LO5** symbolic form, reads:

$$(C^k = P^k + D^k + G^k - \varepsilon)$$

Explain the physical meaning of the different terms in the equation.

- **3B.** Answer the following: (03) CO2 L04
 - a. Does vortex asymmetry play a role anywhere in turbulence?
 - b. List the two shear stress types that appear on the right side of the Reynolds Average Navier-Stokes (RANS) equation?

2B.

2C.

- **3C.** Identify the main difference between Hybrid LES-RANS (02) CO4 L03 and DES (Detached Eddy Simulations)?
- **4A.** The dissipation term ε_{ij} in turbulence models is active for **(05) CO2 LO2** small-scale turbulence. Interpret, how is the small-scale turbulence isotropic?
- **4B.** Explain URANS and the decomposition of instantaneous **(03) CO2 LO5** velocity?
- **4C.** In LES, list the factors that should be considered when **(02) CO1 LO4** computing time-averaged quantities?
- 5A. The region near the wall is very important. let us, again, (05) CO5 L05 consider fully developed channel flow between two infinite plates, the wall region of which is shown in figure 2.



Explain each region of the wall region and explain about Reynold stresses and velocity gradient.

5B. Answer the following:

- a. Explain the cascade process. How large are the largest scales?
- b. Identify the eddies that extract energy from the mean flow and how are these eddies "best" at extracting energy from the mean flow?
- **5C.** Examine the modification of $k \omega$ SST model to obtain **(02) CO3 L04** the $k \omega$ SST DES model

(03) CO2 LO3