Name: **Enrolment No:**	

UPES

End Semester Examination, May 2023

Course: Turbulence Modelling **Semester: II**

Program: M. Tech CFD **Time : 03 hrs.**

Course Code: ASEG 7026 **Max. Marks: 100**

Instructions: Make use of sketch/plots to elaborate your answer. All sections are compulsory.

SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	Write briefly explaining the nature of turbulence. How does statistics help in characterizing such flows?	**[04]**	**CO1**
Q 2	Describe in details any two flows characterized as free turbulent flows.	**[04]**	**CO1**
Q 3	Define the descriptors used for fluctuating components a) Variance b) Root mean square	**[04]**	**CO2**
Q 4	Compare the hydrodynamic and thermal entry lengths for the flow of mercury in a circular tube when the flow is either laminar or turbulent.	**[04]**	**CO2**
Q 5	An aircraft is analyzed using CFD simulation for both High and Low Reynolds number conditions using k-ϵ turbulence model. Answer the questions asked below: a. Provide the expressions of the Wall functions: $u+$ and T^+ b. Give the k-ϵ turbulence model equations for High Reynolds number. Explain in detail the modifications made to the actual k-ϵ turbulence model for solving low Reynolds number condition.	**[04]**	**CO4**

SECTION B
(4Qx10M= 40 Marks)

Q 6	Explain the concept of eddy viscosity and eddy diffusivity. How do they benefit in relation to the mathematical terms created due to time averaging of Navier-Stokes equation.	**[10]**	**CO2**
Q 7	Derive the Prandtl's mixing length model. Explain the relations used for the length and velocity scale.	**[10]**	**CO3**

Q 8	State Kolmogorov's first and second similarity hypothesis. Distinguish between the following ranges: a) Energy containing range b) Inertial Subrange c) Dissipation range **or** Consider a steady flow between two parallel plates. If U is the velocity of the upper plate and the lower plate is stationary. Describe type of flow under following cases; a. positive U and favorable $dp/dx < 0$, b. positive U and adverse $dp/dx > 0$.	**[10]**	**CO2**
Q 9	Give a detailed description of the turbulent boundary layer adjacent to a solid surface. Clearly explaining the inner sub-regions with the following sub-layers; a) The linear sub-layer b) The buffer layer c) the log-law layer	**[10]**	**CO4**
SECTION-C (2Qx20M=40 Marks)			
Q 10	Derive <u>*any one*</u> of the turbulence models clearly stating the transport equation and the various relations used to represent the turbulent viscosity. State the advantage and disadvantage of the turbulence model. a) Standard k-ω model b) Reynolds stress equation model (RSM)	**[20]**	**CO3**
Q 11	Consider a NACA4412 airfoil. CFD study is to be done on the airfoil mainly to analyze the pressure and velocity behavior over the airfoil. Provide the following information: a) Suggest the best turbulence model that can be used for the above analysis. Explain why you have suggested the model and how it is advantageous over other models. b) Write the relevant Reynolds stress equation and the turbulence model equation for the suggested turbulence model. c) Give the detailed boundary conditions suitable for the suggested turbulence model. d) Provide the model constants of the suggested model.	**[20]**	**CO4**