Name: **Enrolment No:**	UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, May 2019

Course : Turbulence Modelling
Course Code: ASEG7026 **Semester : II**
Programme : M.Tech CFD
Time : 03 hrs. **Max. Marks : 100**
Instructions : All questions are compulsory
Assume data if missing.

SECTION A

S. No.		Marks	CO
Q 1	Explain the concept of turbulent diffusivity.	**4**	**CO1**
Q 2	Emphasis on different phases of transition from laminar flow to turbulent flow.	**4**	**CO1**
Q 3	Discuss the significance of correlation function in developing turbulence model.	**4**	**CO2**
Q 4	Convert incompressible continuity equation in its Reynolds averaged form (Instantaneous property = Mean property + Fluctuating property) by applying averaging rules.	**4**	**CO3**
Q 5	Outline the role of eddy viscosity and eddy diffusivity in RANS.	**4**	**CO4**

SECTION B

Q 6	Discuss all the basic properties of turbulent flow in detail	**10**	**CO1**
Q 7	With the help of diagram, explain in detail about the energy cascading mechanism in turbulent flow. OR Compute the time average of the function $u(t) = Ae^{-t/\tau} + B\cos(\omega t)$. Presuming this function is meant to represent a turbulent field variable with zero-mean fluctuations, $B\cos(\omega t)$, superimposed on a decaying time-dependent average, $Ae^{-t/\tau}$, what condition on Δt leads to an accurate recovery of the decaying average? Moreover, what condition on Δt leads to suppression of the fluctuations?	**10**	**CO2**
Q 8	i. Outline the formulation of Large Eddy Simulation (LES) turbulence model. ii. To solve a fluid problem using LES, the problem is partially modelled and partially resolved. By providing proper reasoning, justify the above sentence.	**10**	**CO3**
Q 9	Compare DNS, LES and RANS simulation models. On what parameters, the selection of the simulation depends.	**10**	**CO3**

SECTION-C

Q 10	Illustrate Kolmogorov Universal Law. Emphasis on all the mathematical parameters involved. Discuss first and second hypothesis of Kolmogorov on turbulence in detail.	**20**	**CO2**
Q 11	Emphasis on the formulate following RANS models: i. Mixing Length Model ii. $k-\varepsilon$ model iii. Reynolds Stress Model (RSM) OR	**20**	**CO4**

	Emphasis on the formulate following RANS models: i. Spalart-Allmaras model ii. k – ω model iii. SST k – ω model		

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SECTION A

S. No.		**Marks**	**CO**
Q 1	Explain the concept of turbulent kinetic energy.	**4**	**CO1**
Q 2	Explain diffusion, dissipation and production in turbulent flow.	**4**	**CO1**
Q 3	Discuss in brief about degree of turbulence.	**4**	**CO2**
Q 4	Convert steady continuity equation in its Reynolds averaged form (Instantaneous property = Mean property + Fluctuating property) by applying averaging rules.	**4**	**CO3**
Q 5	Turbulent flows are highly energetic as well as dissipative in nature. Illustrate the phenomenon of transfer and dissipation of energy in turbulence.	**4**	**CO4**

SECTION B

Q 6	With the help of a neat diagram, discuss in details about the turbulent boundary layer. How it differs from laminar boundary layer? Justify your answer.	**10**	**CO1**
Q 7	Derive the equation for the kinetic energy of the average flow field. OR Estimate the boundary layer thicknesses on the underside of the wing of a large commercial airliner on its landing approach. Use the flat-plate results, a chord-length distance of $x = 8$ m, a flow speed of 100 m/s, and a nominal value of $k = 0.4$.	**10**	**CO2**
Q 8	Differentiate Filtered Navier Stokes Equation from its complete form. Underline the significance of Filtered form in turbulence modelling.	**10**	**CO3**
Q 9	Compare DNS, LES and RANS simulation models. On what parameters, the selection of the simulation depends.	**10**	**CO3**

SECTION-C

Q 10	Illustrate the application Probability Density Function and Averaging in modelling the turbulent flow.	**20**	**CO2**
Q 11	Apply Reynold averaging to derive Reynold Averaged Navier Stokes Equation for turbulent flow.	**20**	**CO4**