Name: **Enrolment No:**	UPES UNIVERSITY OF TOMORROW

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, May 2022

Course: Turbulence Modelling **Semester: II**
Program: M. Tech CFD **Time: 03 hrs.**
Course Code: ASEG 7026 **Max. Marks: 100**

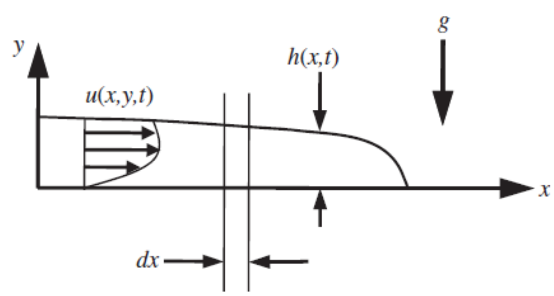
Instructions: Make use of sketch/plots to elaborate your answer. All sections are compulsory

SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	Write a brief on transition of turbulence. What do you mean by hydrodynamic instability? Give examples of flow with and without a point of inflexion.	**[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	For laminar flow over a flat plate, how do the local heat transfer coefficient and the friction coefficient vary with distance from the leading edge?	**[04]**	**CO4**

SECTION B
(4Qx10M= 40 Marks)

Q 6	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]**	**CO2**

Q 7	Compute the time average of the function $u(t) = Ae^{-t/\tau} + B\cos(\omega t)$ using, $$\overline{u^m(x)} = \frac{1}{\Delta t}\int_{t-\Delta t/2}^{t+\Delta t/2} u^m(x,t)dt$$ 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? And, what condition on Δt leads to suppression of the fluctuations?	**[10]**	**CO3**
Q 8	Explain the following terms: a) Cumulative Distribution function (CDF) b) Probability Density function (PDF) c) The Exponential Distribution d) The Normal Distribution	**[10]**	**CO2**
Q 9	Derive the Reynolds-averaged Navier---Stokes equations for incompressible flow. Also give the time-average transport equation for scalar φ. Write a brief note on any two turbulent models of your choice.	**[10]**	**CO4**
SECTION-C (2Qx20M=40 Marks)			
Q 10	A two-dimensional bead of a viscous fluid with density ρ and viscosity μ spreads slowly on a smooth horizontal surface under the action of gravity. Ignoring surface tension and fluid acceleration, determine a differential equation for the thickness $h(x, t)$ of the spreading bead as a function of time.  Fig.1 Gravity-driven spreading of a two-dimensional drop on a flat, stationary surface. The fluid is not confined from above. Hydrostatic pressure forces cause the fluid to move but it is impeded by the viscous shear stress at $y = 0$. The flow is assumed to be symmetric about $x = 0$ so only half of it is shown.	**[20]**	**CO3**

Q 11	Read the cases below and derive the exact solutions of Navier-Stokes equations by considering necessary boundary conditions: a) Steady laminar flow through a straight circular pipe. Consider the Darcy-Weisbach friction factor. b) Long flat plate kept in an infinite viscous fluid which is suddenly accelerated and moves in its plane at a velocity U_0. **OR** a) A steady two dimensional flow between parallel plates kept at a distance h apart. Indicate the velocity distribution. b) Couette flow between parallel plates with top surface moving at a velocity of U_0. Indicate the velocity distribution.	**[20]**	**CO4**