Enrolment No:	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, July 2020

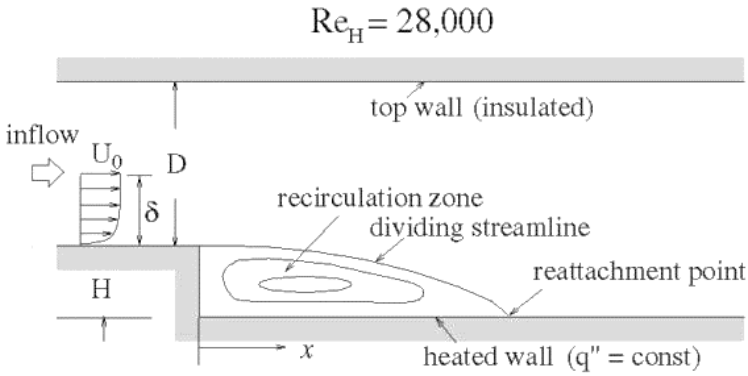
Course: Turbulence Modelling **Semester: IV**
Program: M. Tech CFD **Time: 24 hrs.**
Course Code: ASEG7026 **Max. Marks: 100**

Instructions:

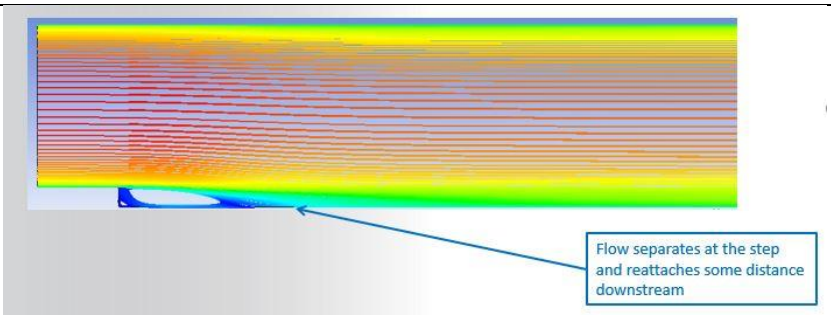
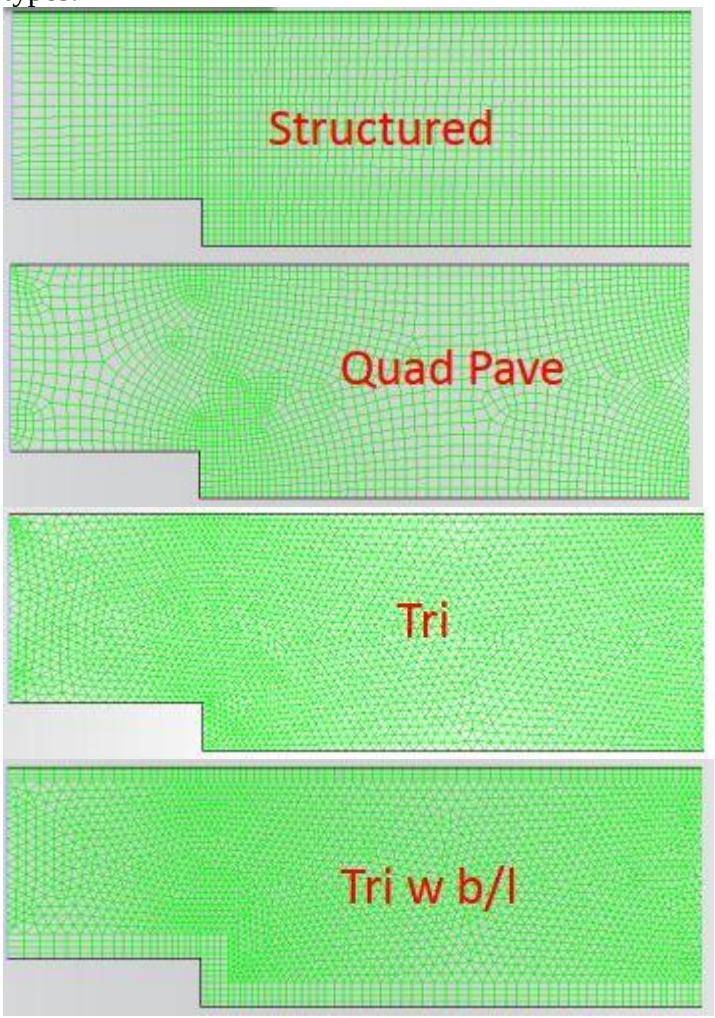
1. **Read the Instruction carefully before attempting**
2. **For Theory based : Type all the answers in a single word document**
3. **For Figures if any : Draw a free hand sketch and insert in the same word document**
4. **For Numerical : Solve it in a paper and insert in the same word document**
5. **Export the figures/plots/graphs and insert into the word document.**
6. **Upload as a single word document that includes all your answers, figures and solved numerical.**

Note: Please upload the word document only, Do not upload PDF and or other format. The answer scripts will be considered for evaluation only through Blackboard. No other mode of submission is acceptable.

SECTION A [Case Based Study] 50 Marks

S. No.		Marks	CO
	Flow over a backwards facing step is a standard test case for turbulence models. You will need to set up and solve turbulent flow problems to compare the results from different turbulence models with each other and with experimental data. You will also examine how the results are affected by boundary conditions.  The simulation should enable you to predict accurately the reattachment point.		

NOTE: The submission time of the Question Paper Answer Sheet is 24 hrs from the scheduled time (*exceptional provision due to extraordinary circumstance due to COVID-19 and due to internet connectivity issues in the far-flung areas*).
No Submission will be entertained after 24 Hrs

	 44.2 m/s is the velocity corresponding to the mass flow rate that results from matching the experimental velocity profile at the location of the inlet in this mesh.		
Q 1	Select an appropriate turbulence model and compare your result for the following grid types:  Chose an appropriate parameter to compare all the grids and plot it on a single graph. Insert the figures of your mesh and the plot into the word document.	**20**	**CO4**

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Q 2	Plot y+ along the bottom wall for the above grids. Insert the figures in the word document. Display velocity vectors for the best case from above.	**10**	**CO4**
Q 3	The experimental data were published as skin friction coefficient. They have been converted from skin friction coefficient to wall shear stress for the file x-wall-shear-stress-ds (Available on blackboard), using U=44.2 m/s and density = 1.18 kg/m3. The reason for doing this is x-shear stress is immediately available as a variable while skin friction coefficient would require defining additional expressions. Compare your result with the experiment.	**20**	**CO4**
SECTION B [Numerical and Short Answers] 50 Marks			
Q 4	Write briefly explaining the nature of turbulence. How does statistics help in characterizing such flows?	**10**	**CO2**
Q 5	Describe in details any two flows characterized as free turbulent flows	**10**	**CO1**
Q 6	Consider a CFD simulation of an Aircraft. The aircraft is analyzed 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 low Reynolds number. c. Explain in detail the modifications made to the actual k-ϵ turbulence model for solving low Reynolds number condition.	**15**	**CO3**
Q 7	Consider the flow of oil in a circular tube. How will the hydrodynamic and thermal entry lengths compare if the flow is laminar? How would they compare if the flow is turbulent? What would be the changes to your conclusions if the fluid is changed to mercury?	**10**	**CO3**
Q 8	What is the effect of surface roughness as boundary condition for a turbulent flow?	**5**	**CO1**

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