Name: **Enrolment No:**	

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
Online End Semester Examination, June 2021

Course: Fluid Structure Interactions **Semester: II**
Program: M. Tech CFD **Time: 03 hrs.**
Course Code: ASEG 7036P **Max. Marks: 100**
Pages: 04
Instructions: Make use of sketch/plots to elaborate your answer. All sections are compulsory

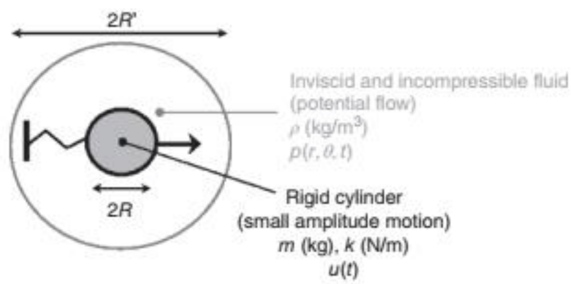
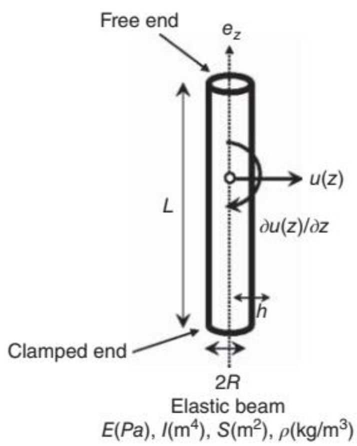
SECTION A (30 marks)

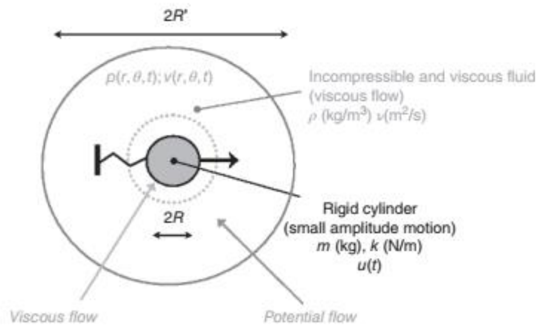
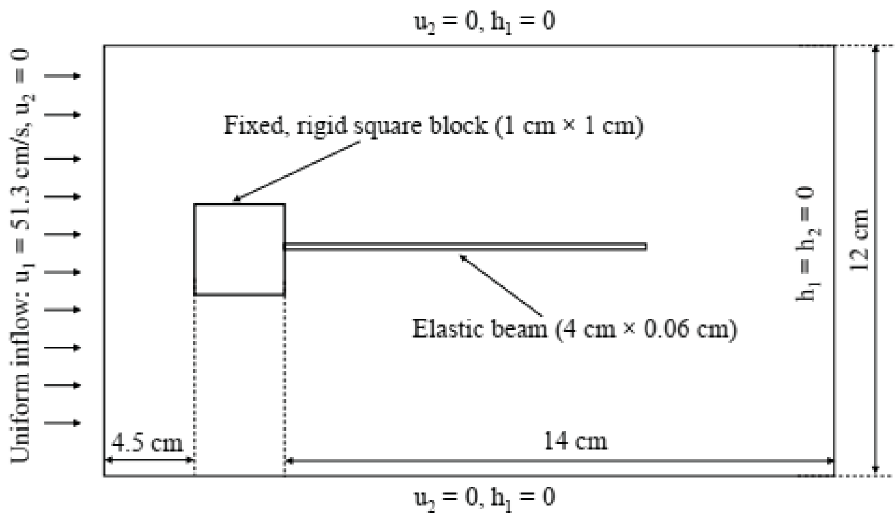
1. Each Question will carry 5 Marks
2. Instruction: Type your answers in the provided space

S. No.		Marks	CO
Q 1	Consider the dynamics of a structure in airflow and the dynamics of the same structure in water flow. In which case is the mass number higher? Why?	**[05]**	**CO2**
Q 2	Which quantities are involved in the kinematic boundary condition? Provide explanation. 1. Fluid's and solid's temperatures 2. Fluid's and solid's velocities 3. Fluid's and solid's displacements 4. Fluid's and solid's stresses at the boundary	**[05]**	**CO1**
Q 3	State if the below mentioned claims are true or false. Explain appropriately. 1. “Pressure gradients in fluids may induce added stiffnesses.” 2. “If viscous effects are neglected, there is no added mass”	**[05]**	**CO1**
Q 4	State the factors needed to describe the effect of a fluid with a free surface in a moving tank on the tank’s dynamics.	**[05]**	**CO2**
Q 5	Consider a solid's oscillation with an amplitude of 10cm, at a frequency of 1Hz, perpendicularly to a flow at 10m/s. Is it possible to use the quasi-static approach to study this problem?	**[05]**	**CO3**
Q 6	What is stall flutter? State if the phenomenon of stall flutter is static or dynamic instability.	**[05]**	**CO3**

SECTION B (50 marks)

1. **Each question will carry 10 marks**
2. **Instruction: Write short/brief notes, scan and upload the document**

Q 7	Derive the equations to express the analytical modelling of the fluid structure interaction considering the cylinder to be surrounded by potential flow. 	**[10]**	**CO2**
Q 8	Consider the bending motion of a straight beam of circular section with mixed/clamped boundary conditions. The beam geometry is defined by its section radius R, thickness h, length L; relevant material properties are the density ρ and Young's modulus E.  The displacement and the rotation at the clamped end are null, as well as the shear moment and the shear force at the free end: $u\|_{z=0} = 0 \quad \frac{\partial u}{\partial z}\Big\|_{z=0} = 0 \quad +EI\frac{\partial^2 u}{\partial z^2}\Big\|_{z=L} = 0 \quad -EI\frac{\partial^3 u}{\partial z^3}\Big\|_{z=L} = 0$ State the governing equation and suggest a numerical method to solve for the unknown variables. What will be the effect of higher order shape functions? Discuss the possible mode shapes of bending modes in term of displacement.	**[10]**	**CO3**

<table>
<tr><td>Q 9</td><td>What are the mathematical challenges faced in computing the unknown variables in a fluid structure interaction?</td><td>[10]</td><td>CO3</td></tr>
<tr><td>Q 10</td><td>Derive the equations to express the analytical modelling of the fluid structure interaction considering the cylinder to be surrounded by viscous flow.

</td><td>[10]</td><td>CO4</td></tr>
<tr><td>Q 11</td><td>Distinguish between strong and weak coupling. State clearly using equations and examples.</td><td>[10]</td><td>CO4</td></tr>
<tr><td colspan="4">SECTION-C (20 marks)
1. Question carries 20 Marks and has internal choice.
2. Instruction: Write long answer, scan and upload the document</td></tr>
<tr><td>Q 12</td><td>Consider a 2D flow past a thin elastic beam attached to a fixed, rigid square block. This test problem was proposed in Wall (1999) to study the accuracy and robustness of FSI methods. The problem setup is shown in the below figure. A uniform inflow velocity of 51.3 cm /s drives the flow. The lateral boundaries are assigned zero normal velocity and zero tangential stress. Zero-traction boundary condition is applied at the outflow.

</td><td>[20]</td><td>CO5</td></tr>
</table>

The fluid density and viscosity are 1.18×10^{-3} g/cm^3 and 1.82×10^{-4} g/cm-s, respectively, resulting in a Reynolds number of 100 based on the edge length of the block. The beam is modeled as a solid made of the neo-Hookean material. The density of the beam is 0.1 g/cm^3, and the Young's modulus and Poisson's ratio are 2.5×10^{6} g/cm-s^2 and 0.35, respectively.

Suggest the proper FSI method that can be employed to compute the results.

Figure shows the velocity vectors and pressure at different instants.

- What can you say about the loading characteristic on the thin plate in terms of deformation?
- A note on the vortices developed and the process of causing oscillations.
- Further suggestions on improving the results.