Name: Enrolment No:	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
Online End Semester Examination, December 2020

Course: Applied Fluid Mechanics **Semester: III**
Program: B. Tech ASE, ASE + AVE **Time: 03 hrs.**
Course Code: MECH 2002 **Max. Marks: 100**
Pages: 04
Instructions: Make use of sketch/plots to elaborate your answer. All sections are compulsory

SECTION A (30 marks)

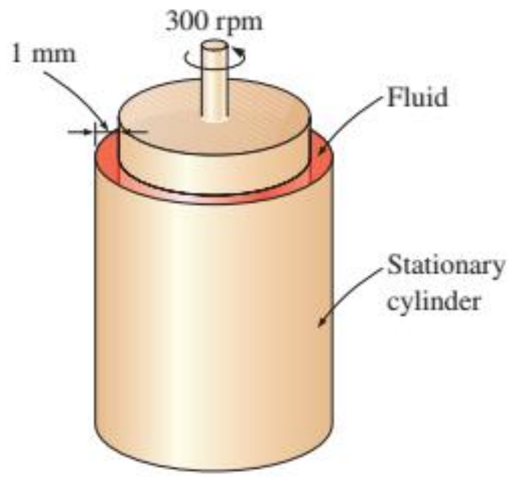
1. Each Question will carry 5 Marks
2. Instruction: Type your answers in the provided space

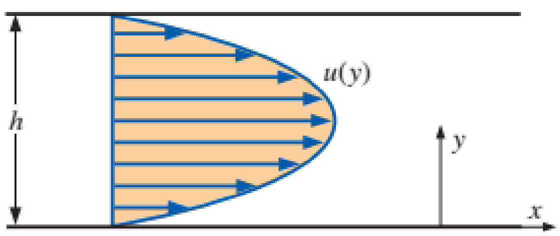
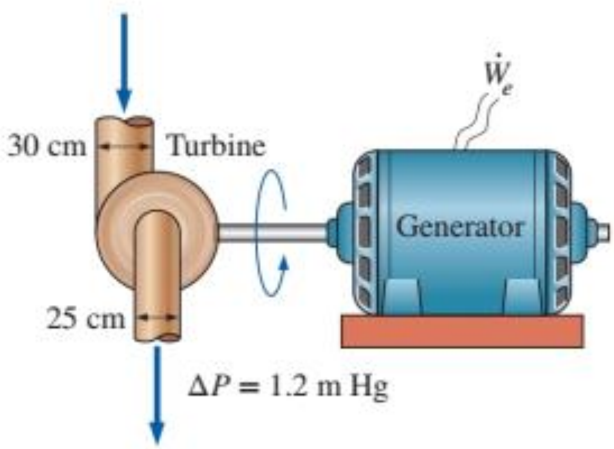
S. No.		Marks	CO
Q 1	A steady, incompressible, two-dimensional velocity field is given by $$\vec{V} = (u, v) = (0.65 + 1.7x)\vec{i} + (1.3 - 1.7y)\vec{j}$$ where the *x*- and *y*-coordinates are in meters and the magnitude of velocity is in *m/s*. The *x*- and *y*-component of material acceleration a_x and a_y at the point ($x = 0$ *m*, $y = 0$ *m*), respectively, in m/s^2, are (a) **0.37, −1.85** (b) **−1.7, 1.7** (c) **1.105, −2.21** (d) **1.7, −1.7** (e) **0.65, 1.3**	**[05]**	**CO2**
Q 2	The static and stagnation pressures of a fluid in a pipe are measured by a piezometer and a pitot tube. The heights of the fluid in the piezometer and pitot tube are measured to be 2.2 *m* and 2.0 *m*, respectively. If the density of the fluid is 5000 kg/m^3, the velocity of the fluid in the pipe is (a) **0.92 m/s** (b) **1.43 m/s** (c) **1.65 m/s** (d) **1.98 m/s** (e) **2.39 m/s**	**[05]**	**CO1**
Q 3	A 9-*m*-diameter hot air balloon is neither rising nor falling. The density of atmospheric air is 1.3 kg/m^3. The total mass of the balloon including the people on board is (a) **496 kg** (b) **458 kg** (c) **430 kg** (d) **401 kg** (e) **383 kg**	**[05]**	**CO1**
Q 4	Consider water flow through a horizontal, short garden hose at a rate of 30 *kg/min*. The velocity at the inlet is 1.5 *m/s* and that at the outlet is 14.5 *m/s*. Disregard the weight of the hose and water. Taking the momentum-flux correction factor to be 1.04 at both the inlet and the outlet, the anchoring force required to hold the hose in place is (a) **2.8 N** (b) **8.6 N** (c) **17.5 N** (d) **27.9 N** (e) **43.3 N**	**[05]**	**CO2**
Q 5	It is observed that water at 20°C rises up to 20 *m* height in a tree due to capillary effect. The surface tension of water at 20°C is $\sigma_s = 0.073$ *N/m* and the contact angle is 20°. The maximum diameter of the tube in which water rises is (a) **0.035 mm** (b) **0.016 mm** (c) **0.02 mm** (d) **0.002 mm** (e) **0.0014 mm**	**[05]**	**CO3**

Q 6	Air at 1 *atm* and 20°C is to be transported in a 60-*m*-long circular steel duct at a rate of 5100 *L/min*. The roughness of the duct is 0.25 *mm*. If the pressure drop in the pipe is not to exceed 90 *Pa*, the maximum velocity of the air is (a) **3.99 *m/s*** (b) **4.32 *m/s*** (c) **6.68 *m/s*** (d) **7.32 *m/s*** (e) **8.90 *m/s***	**[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	The viscosity of a fluid is to be measured by a viscometer constructed of two 75-*cm*-long concentric cylinders. The outer diameter of the inner cylinder is 15 *cm*, and the gap between the two cylinders is 1 *mm*. The inner cylinder is rotated at 300 *rpm*, and the torque is measured to be 0.8 *N·m*. Determine the viscosity of the fluid.  	**[10]**	**CO2**
Q 8	On a day in which the local atmospheric pressure is 99.5 kPa, answer each of the following: (a) Calculate the column height of mercury in a mercury barometer in units of meters, feet, and inches. (b) Rahul is concerned about mercury poisoning, so he builds a water barometer to replace the mercury barometer. Calculate the column height of water in the water barometer in units of meters, feet, and inches. (c) Explain why a water barometer is not very practical. (d) Ignoring the practicality issue, which of the two (mercury or water) would be more precise? Explain.	**[10]**	**CO3**

Q 9	State the Reynolds Transport Theorem and apply it to the conservation of momentum achieve the formulation for the linear momentum equation. Validate the achieved formulation by deriving the momentum equation at a point in a fluid enclosed by an elementary control volume.	**[10]**	**CO3**
Q 10	Consider fully developed two-dimensional **Poiseuille flow**—flow between two infinite parallel plates separated by distance *h*, with both the top plate and bottom plate stationary, and a forced pressure gradient *dP/dx* driving the flow as illustrated in Fig. (*dP/dx* is constant and negative.) The flow is steady, incompressible, and two-dimensional in the *xy*-plane. The velocity components are given by $$u = \frac{1}{2\mu}\frac{dP}{dx}(y^2 - hy) \qquad v = 0$$ where μ is the fluid's viscosity. Is this flow rotational or irrotational? If it is rotational, calculate the vorticity component in the *z*-direction. Do fluid particles in this flow rotate clockwise or counterclockwise?  	**[10]**	**CO4**
Q 11	Water enters a hydraulic turbine through a 30-*cm*-diameter pipe at a rate of 0.6 m^3/s and exits through a 25-*cm*-diameter pipe. The pressure drop in the turbine is measured by a mercury manometer to be 1.2 *m*. For a combined turbine– generator efficiency of 83 percent, determine the net electric power output. Disregard the effect of the kinetic energy correction factors.  	**[10]**	**CO4**

SECTION-C (20 marks)

1. Question carries 20 Marks.
2. Instruction: Write long answer, scan and upload the document

Q 12			
Q 12	See below	**[20]**	**CO5**

Q 12 Water flows at mass flow rate $\dot{m}$ through a 90º vertically oriented elbow of elbow radius R (to the centerline) and inner pipe diameter D as sketched. The outlet is exposed to the atmosphere. (Hint: This means that the pressure at the outlet is atmospheric pressure.) The pressure at the inlet must obviously be higher than atmospheric in order to push the water through the elbow and to raise the elevation of the water. The irreversible head loss through the elbow is h_L.
Assume that the kinetic energy flux correction factor α is not unity, but is the same at the inlet and outlet of the elbow ($\alpha_1 = \alpha_2$). Assume that the same thing applies to the momentum flux correction factor β (i.e., $\beta_1 = \beta_2$).

(a) Using the head form of the energy equation, derive an expression for the gage pressure $P_{gage,1}$ at the center of the inlet as a function of the other variables as needed.

(b) Plug in these numbers and solve for $P_{gage,1}$: ρ = 998.0 *kg/m*^{3}, D = 10.0 *cm*, R = 35.0 *cm*, h_L = 0.259 *m* (of equivalent water column height), $\alpha_1 = \alpha_2 = 1.05$, $\beta_1 = \beta_2 = 1.03$, and $\dot{m}$ = 25.0 *kg/s*. Use g = 9.807 *m/s*^{2} for consistency. Your answer should lie between 5 and 6 *kPa*.

(c) Neglecting the weight of the elbow itself and the weight of the water in the elbow, calculate the *x* and *z* components of the anchoring force required to hold the elbow in place. Your final answer for the anchoring force should be given as a vector,

$$\vec{F} = F_x\vec{i} + F_z\vec{k}$$

(d) Repeat Part (c) without neglecting the weight of the water in the elbow. Is it reasonable to neglect the weight of the water in this problem?