Name:

Enrolment No:

UPES

End Semester Examination, December 2024

Program Name: B.Tech (Mechanical and ADE) — **Semester : III**

Course Name: Fluid Mechanics — **Time : 3 hrs**

Course Code: MECH2079 — **Max. Marks : 100**

Nos. of page(s): 03

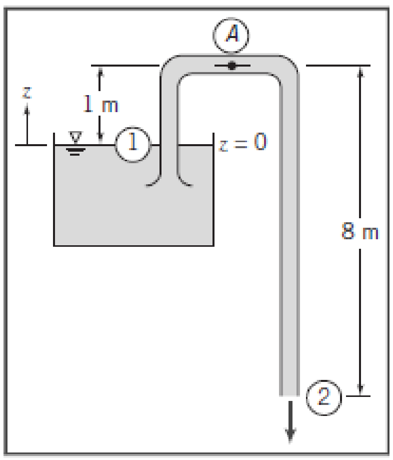
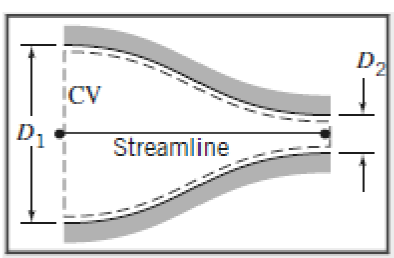
Instructions: Assume suitable values of variables/parameters, if not given in the problem.

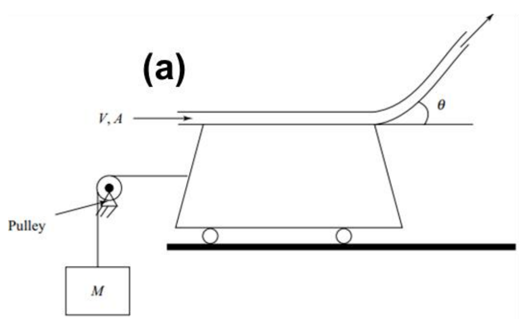
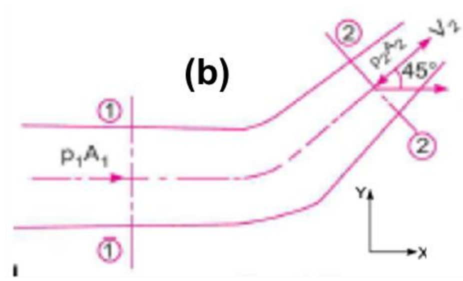
SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	Define Reynolds Number. Write down its mathematical expression and its physical significance in fluid mechanics.	**4**	**CO1**
Q 2	Discuss the stability criteria for floating and completely submerged bodies.	**4**	**CO1**
Q 3	(i) Write short note on "Vena-contracta". (ii) Enlist the limitations of Bernoulli's theorem.	**4**	**CO1**
Q 4	Explain the concept of boundary layer. Discuss the development of the boundary layer flow over a flat plate.	**4**	**CO2**
Q 5	A Pitot-static tube is used to measure the velocity of water flowing in a pipeline. If the water velocity is 2.5 m/s^2 and the coefficient of the tube is 0.98, calculate the differential height shown by a mercury manometer connected to the Pitot-static tube. Assume the density of water is 1000 kg/m^3 and the density of mercury is 13,600 kg/m^3.	**4**	**CO2**

SECTION B
(4Qx10M= 40 Marks)

S. No.		Marks	CO
Q 6	For a two-dimensional fluid flow, the velocity potential function is given by: $$\Phi = x^3 - 3xy^2 + 4y$$ (i) Derive the velocity components in the x and y-directions (u and v) from the given velocity potential. (ii) Verify that the velocity components satisfy the conditions for continuity and irrotationality. (iii) Derive the corresponding stream function (ψ) and determine the flow rate between the streamlines passing through the points (1, 0) and (1, 2).	**10**	**CO3**

Q 7	If, cross sectional area of pipe and throat of a venturimeter are a_1 and a_2 respectively. Then, derive the expression of actual flow rate: $$Q_{act} = C_d * \frac{a_1 a_2}{\sqrt{{a_1}^2 - {a_2}^2}} * \sqrt{2gh}$$ Where, "*h*" is difference of pressure head and "C_d" is coefficient of discharge.	**10**	**CO3**
Q 8	The drag force, *F*, on a smooth sphere depends on the relative speed, *V*, the sphere diameter, *D*, the fluid density, ρ, and the fluid viscosity, μ. Obtain a set of dimensionless groups that can be used to correlate experimental data.	**10**	**CO3**
Q 9	A U-tube acts as a water siphon. The bend in the tube is 1 m above the water surface; the tube outlet is 7 m below the water surface. The water issues from the bottom of the siphon as a free jet at atmospheric pressure. Determine the speed of the free jet and the minimum absolute pressure of the water in the bend (ρ_w = 1000 kg/m^3).  **OR** Water flows steadily through a horizontal nozzle, discharging to the atmosphere. At the nozzle inlet the diameter is D_1; at the nozzle outlet the diameter is D_2. Derive an expression for the minimum gauge pressure required at the nozzle inlet to produce a given volume flow rate, *Q*. Evaluate the inlet gage pressure if *D*1 =75 mm, D_2 =25 mm, and the desired flow rate is 0.02 m^3/s. 	**10**	**CO4**

SECTION-C **(2Qx20M=40 Marks)**			
Q 10	(a) Two large parallel plane surfaces are separated by a distance of 2.4 cm, with the space between them filled with glycerin. Determine the force required to drag a very thin plate with a surface area of 0.5 m^2 at a velocity of 0.6 m/s, given that the plate is positioned 0.8 cm from one of the surfaces. Assume the dynamic viscosity of glycerin is 0.81 N·s/m^2. **(10 M)** (b) A passenger car with frontal projected area of 1.5 m^2 travels at 56 km/hr. Determine the power required to overcome wind resistance if the drag coefficient of car is 0.4. For the same power extended in overcoming resistance, find possible percentage change in speed if drag coefficient is reduced to 0.32 by streamlining the car body **(**Drag coefficient, $C_D = F_D / ((1/2)\,\rho V^2 A_p)$). **(10 M)**	**20**	**CO4**
Q 11	A jet of water issuing from a stationary nozzle with a uniform velocity, *V*, strikes a frictionless turning vane mounted on a cart, as shown in figure (a) below. The vane turns the jet through an angle θ. The area corresponding to the jet velocity, *V*, is *A*. An external mass, *M*, is connected to the cart through a frictionless pulley. Determine the magnitude of *M* required to hold the cart stationary. Assume the ground to be frictionless.  **OR** A 45° reducing bend is connected in a pipeline, the diameters at the inlet and outlet of the bend being 600 mm and 300 mm respectively. Find the force exerted by water on the bend if the intensity of pressure at the inlet to the bend is 8.829 N/cm^2 and rate of flow of water is 600 litres/s (1 m^3 = 1000 lits, refer figure (b) for schematic). **Use following relationship as per requirement:** $\left.\frac{dN}{dt}\right)_{\text{system}} = \frac{\partial}{\partial t}\int_{CV} \eta\,\rho\, d\forall + \int_{CS} \eta\,\rho\,\vec{V}\cdot d\vec{A}$	**20**	**CO4**