ABC

Birla Institute of Technology and Science, Pilani

Semester I Session: 2022-2023

CHE F212 FLUID MECHANICS

Comprehensive Test Part A

Date: 27/12/2022 Maximum Marks: 40

Duration: 60 minutes Weightage: 13.33 %

CLOSED BOOK Part A (Marks =40)

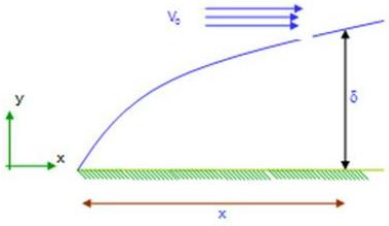
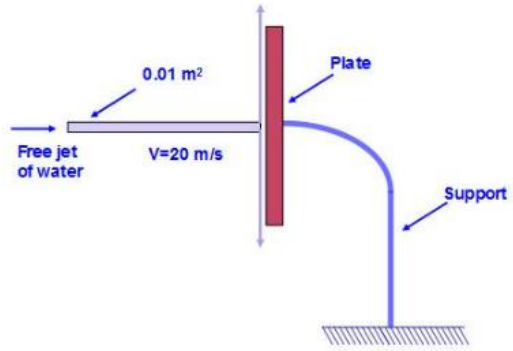
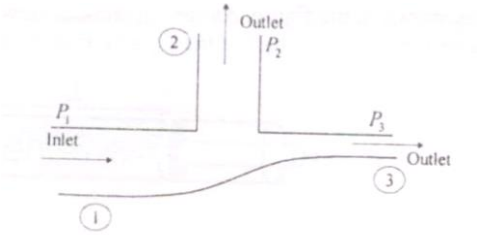
Name:	ID No.

Q 1 **[2 x 10 = 20]**

(i)	The pressure drop required for fluidizing a coal bed with a liquid petroleum fraction of viscosity 0.015 Ns/m^2 is 10^3 N/m^2. The pressure drop required for fluidizing the same bed with an oil of viscosity 0.03 Ns/m^2 is _____N/m^2. Assume flow is turbulent.
(ii)	A plant has a water tank mounted on the top of a 27 m platform. The tank is 10 m high. Estimate the height of water in the tank if a pressure gauge on the second floor at the height of 5 m from the ground reads 2.7 bar.
(iii)	The shear stress-shear rate relationship for a liquid, whose apparent viscosity decreases with increasing shear rate, is known as _____
(iv)	What is the bed pressure drop expressed in cm of water (manometer) in an air-fluidized bed of catalyst particles (ρ_p= 200 kg/m^3, D_p = 0.05 cm) of 60 cm bed depth and bed porosity of 0.5?
(v)	A pipe of ID 4 m is bifurcated into two pipes of ID 2 m each. If the average velocity of water flowing through the main pipe is 5 m/s, the average velocity through the bifurcated pipes is _____m/s
(vi)	Consider a soap film bubble of diameter D. If the external pressure is P_0 and the surface tension of the soap film is σ , the expression for the pressure inside the bubble is_____
(vii)	The terminal settling velocity of a 6mm diameter glass sphere (density= 2500 kg/m^3) in a viscous Newtonian liquid (density= 1500 kg/m^3) is 100 μm/s. If the particle Reynolds number is small, what is the viscosity of the liquid (in Pa.s)?
(viii)	The bed height at the incipient fluidization is 0.075 m, and the corresponding voidage is 0.38. If the voidage of the bed increases to 0.5, what would be the bed height (in m)?
(ix)	What is the NPSH value (in m) for pumping toluene (density = 866 kg/m^3 and vapor pressure = 1.1 atm) from the tank (toluene level is 3 m and tank is open to atmosphere) considering no friction in the suction line?
(x)	What is the value of drag coefficient for a sphere (6 mm diameter) falling through castor oil (density = 970 kg/m^3 and viscosity = 0.9 Pa s) at a terminal speed of 60 mm/s?

Q 2 **[4 x 5 = 20]**

(i)	Air flows through a packed bed of a powdery material of 1 cm depth at a superficial gas velocity of 1 cm/sec and observes the pressure drop of 98.1 Pa. The bed has a porosity of 0.4. Assuming that Kozeny-Carman equation is valid for the range of study, estimate the particle size (in mm) of the powder. Data: ρ (air) = 1.23 kg/m^3, μ (air) = 1.8×10^{-5} kg/m.s.

(ii)	For flow over a flat plat wherein, a laminar boundary layer is present for the case of a zero pressure gradient, the parabolic profile for velocity u is given by, $u = a_1 y + a_2 y^2$ for $y \le \delta$ $u = V_0$ for $y \ge \delta$ Find a_1 and a_2. V_0 is the free stream velocity 
(iii)	A free jet of water with a cross-sectional area of 0.01 m^2 and a velocity of 20 m/s strikes a plate and then flows in the plane parallel to the plate, as shown in the figure below. What is the horizontal component of the force (in N) on the support? 
(iv)	A pipeline system carries crude oil of density 800 kg/m^3. The volumetric flow rate at point 1 is 0.28m^3/s. The cross-sectional area of branches 1, 2 and 3 are 0.012, 0.008 and 0.004 m^2, respectively. All three branches are in the horizontal plane, and the friction is negligible. If the pressure at points 1 and 3 are 270 kPa and 240 kPa, respectively, what is the velocity at point 2 (in m/s)? 
(v)	For an incompressible flow, the x and y components of the velocity vector are $v_x = 2(x + y); v_y = 3(y + z);$ where x, y, and z are in meters and velocities are in m/s. What is the z-component of the velocity vector (v_z) of the flow for the boundary condition $v_z = 0$ at z = 0.

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Comprehensive Test Part B

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CLOSED BOOK Part B (Marks =40)

Q 1 **[15]**

Nikuradse developed a semi-theoretical correlation for f vs Re for steady turbulent flow in smooth pipes ($10^5 < Re < 10^7$)

$$\frac{1}{\sqrt{f}} = 1.75\ln(Re\sqrt{f}) - 0.4$$

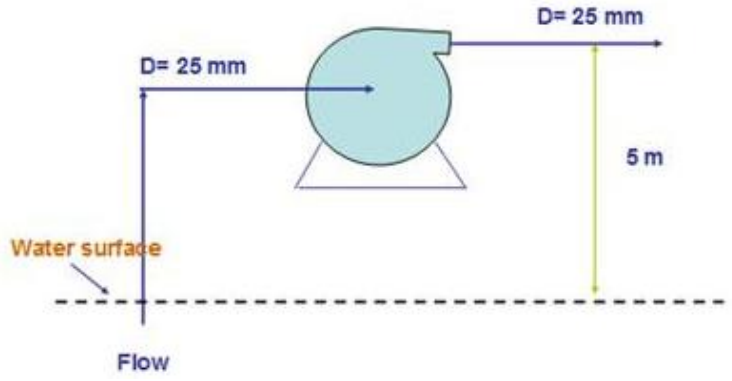
Toluene (ρ = 866 kg/m^3, μ = 0.0008 Ns/m^2) is to be conveyed through a 100 m pipeline of diameter 0.2 m. What is the maximum flow rate of toluene in kg/sec that can be maintained if the frictional pressure loss does not exceed 10 kN/m^2?

Q 2 **[10]**

Water flowing at 1.5 L/s in a 0.05 m diameter tube is metered by means of a simple orifice of diameter 0.025 m. If the discharge coefficient is 0.62, what will be the reading on a mercury-under-water manometer connected to the meter? Density of water = 1000 kg/m^3; Viscosity of water = 0.001 Ns/m^2; Density of mercury = 13600 kg/m^3.

Q 3 **[10]**

In the figure given below, calculate the power required by the pump to deliver water at 3 m/s from a pond. The inner diameter of the pipe is 25 mm. Neglect all losses in the pipe. The density of water is 1000 kg/m^3.



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CHE F212 FLUID MECHANICS

Comprehensive Test Part C

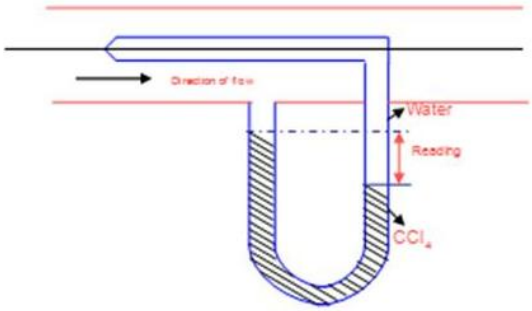
Date: 27/12/2022 Maximum Marks: 40

Duration: 60 minutes Weightage: 13.33 %

OPEN BOOK Part C (Marks =40)

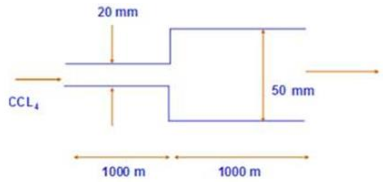
Q 1 **[20]**

Water flows through a 30 mm internal diameter pipe at atmospheric pressure. The pitot tube measures the water velocity at the centre of the pipe, as shown in Figure. The pressure difference between the impact and static tubes is 20 cm of carbon tetrachloride (density = 1500 kg/m^3). Calculate the volumetric flow rate through the pipe in cubic meters per hour. The viscosity of water is 1 cP.



Q 2 **[20]**

In a delivery line for carbon tetrachloride at the constant flow rate of 4×10^{-5} m^3/s, the first 1000 m long section is of 20 mm inside diameter smooth pipe followed by another 1000 m long section of 50 mm inside diameter smooth pipe as shown in the figure below:



Estimate the pressure drop over the entire length of the delivery line. For carbon tetrachloride, ρ (density) = 1500 kg/m^3, μ (viscosity) = 10^{-3} Pa.s.