Q1	
Q2	
Q3	
Total	

Birla Institute of Technology and Science, Pilani

Semester I Session: 2023-2024

CHE F212 FLUID MECHANICS

Comprehensive Test Part A

Date: 20/12/2023 Maximum Marks: 60

Duration: 90 minutes Weightage: 20 %

CLOSED BOOK Part A (Marks =60)

Name:	ID No.

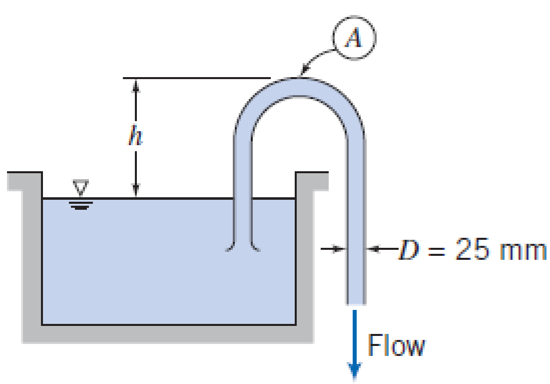
Note: This is a question paper cum answer sheet for part- A. Use the last few pages of the main answer book for rough work. Consider gravitational constant (g) = 9.81 ms^{-2}.

Q 1 **[4 x 5= 20]**

(a)	Consider the velocity field $V = ax\hat{i} + by(1+ct)\hat{j}$, where a =b =2 s^{-1} and c = 0.4 s^{-1}. Coordinates are measured in meters. For the particle that passes through the point (x, y) = (1, 1) at the instant t = 0, what is the coordinate (x, y) in meters at time 0.5 s. Answer = (x,y) = (_____________,_____________) (don't write expression)
(b)	A block of mass 10 kg (size = 0.25m x 0.25 m x 0.25 m) is pulled up an inclined surface on which there is a film of oil (the oil film is 0.025 mm thick and viscosity is 0.1 Pas). Find the steady speed of the block if it is released = ______________m/s. Assume the velocity distribution in the oil film is linear. The surface is inclined at an angle of 30° from the horizontal.
(c)	Consider the flow of an incompressible fluid between two parallel plates separated by a distance 2H. If the velocity profile is given by: $$u = u_c\left(1 - \frac{y^2}{H^2}\right)$$ Where u_c is the centerline velocity, and its value is 6 m/s, What is the average velocity of the flow = ________________m/s. Assume the depth of the plates is w.

(d)	The liquids chlorobenzene (1109 kg/m^3) and aqueous wash liquid (1020 kg/m^3) are to be separated in a tubular centrifuge bowl with an inside diameter of 150 mm rotating at 8000 rpm. The free liquid surface inside the bowl is 40 mm from the axis of rotation. If the centrifuge bowl is to contain equal volumes of two liquids, what should be the radial distance from the rotational axis to the top of the overflow dam for the heavy liquid? Ans =_______________mm

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

(a)	Incompressible fluid flows steadily through a plane diverging channel. At the inlet, of height H, the flow is uniform with magnitude $V_1 = 5$ m/s. At the outlet, of height 2H, the velocity profile is $V_2 = V_m \cos\left(\frac{\pi y}{2H}\right)$ Where y is measured from the channel centerline. What is the value of V_m = _____________m/s ?
(b)	A pitot-static tube is used to measure the speed of air (density = 1.23 kg/m^3) at standard conditions at a point in a flow. To ensure that the flow may be assumed incompressible for calculations of engineering accuracy, the speed is to be maintained at 100 m/s or less. Determine the manometer deflection in millimetres of water (density = 999 kg/m^3) that corresponds to the maximum desirable speed. Ans = _____________mm
(c)	The water flow rate through the siphon is 5 L/s, its temperature is 20 °C, and the pipe diameter is 25 mm. Compute the maximum allowable height, *h*, so that the pressure at point A is above the vapor pressure of the water. (Assume the flow is frictionless and vapor pressure is 2.358·kPa) Height = ___________m 

(d)	Data measured during tests of a centrifugal pump at 3500 rpm are given in the table below: **Parameter** / **Inlet Section** / **Outlet Section** gage pressure, p [kPa]: 95.2 / 412 elevation above datum, z [m]: 1.25 / 2.75 avg speed of flow, V [m/s]: 2.35 / 3.62 The working fluid is water. The total head rise across the pump = ______________m

Parameter	Inlet Section	Outlet Section
gage pressure, p [kPa]	95.2	412
elevation above datum, z [m]	1.25	2.75
avg speed of flow, V [m/s]	2.35	3.62

Q 3 **[4 x 5= 20]**

(a)	The drag characteristics of a blimp (airship) 5 m in diameter and 60 m long are to be studied in a wind tunnel. If the speed of the blimp through still air is 10 m/s, and if a 1/10 scale model is to be tested, what airspeed in the wind tunnel is needed for dynamic similarity=____________m/s? Assume the same air temperature and pressure for both the prototype and model.
(b)	A parachute was used during part of the landing sequence to deposit the Spirit rover on the Martian surface. The parachute had a fully-open, projected diameter of 14.1 m and was designed to slow the landing package (lander and rover) to a terminal speed of 65 m/s (retro-rockets were used to bring the landing package to a near zero vertical velocity). If the mass of the landing package was 544 kg, what was the drag coefficient for the parachute = __________? Assume the gravitational acceleration on Mars is 3.72 m/s^2 and that the density of the Martian atmosphere near the surface is 0.016 kg/m^3 .
(c)	A fluid velocity field is given by, $\mathbf{u} = (cy^2)\hat{\mathbf{i}} + (cx^2)\hat{\mathbf{j}}$. Where c is a constant, determine the points in the flow field where the acceleration is zero. Ans = ___________
(d)	A packed bed is composed of cubes 0.02 m on a side. The bulk density of the packed bed, with air, is 980 kg/m^3. The density of the solid cubes is 1500 kg/m^3. Calculate the void fraction (e) of the bed =____________. Determine the sphericity of the cubes =_________________.