BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
SEMESTER I, 2017-18
CHE F212: FLUID MECHANICS
COMPREHENSIVE EXAMINATION (CLOSED BOOK)

Date: 05/12/2017 **Duration: 3 Hrs**
Day: Tuesday **Max. Marks: 120**

Instructions:
1. Take suitable assumption wherever necessary
2. Data: P_{atm}=101.325 kPa; Individual Gas Constant for Air, R_{air} = 286.9 J/kg.K; ρ_{air} = 1.2 kg/m^3 and ρ_{water} = 1000 kg/m^3; g = 9.81 m/s^2
3. Start a new answer on a new page.
4. Numbers in square bracket to the right indicate marks allotted to that question.

(CLOSED BOOK; Maximum: 2 Hr 15 Min)

Q.1) Discuss the following dimensionless number in the tabular form as per the sample table: **[20]**
(i) Reynolds number, (ii) Froude Number, (iii) Euler Number,
(iv) Cavitation number, (v) Weber Number.

Sample Table: Example of Cauchy Number.

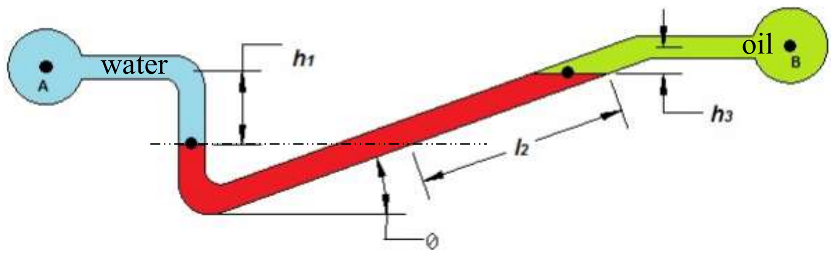
DIMENSION-LESS GROUPS	NAME	INTERPRETATION (INDEX OF FORCE RATIO)	TYPES OF APPLICATION
$\frac{\rho V^2}{E_v}$	Cauchy Number	$\frac{Inertial\ force}{Compressibility\ force}$	Useful for analyzing fluid flow dynamics problems where compressibility is a significant factor.

Q.2) Consider a piston-cylinder apparatus filled with an inert gas. At some instant when piston is at a distance of "L" from the closed end of the cylinder, the gas density is uniform at ρ and the piston begins to move away from the closed end at velocity V. Assume that the gas velocity is one-dimensional and proportional to the distance from the closed end; it varies linearly from zero at the closed end to $u = V$ at the piston. Obtain an expression for: **[10]**
(i) the average density as a function of time.
(ii) the rate of change of gas density at this instant.

Q.3) **A.** A jet aircraft flies at a speed of 825 km/h at an altitude of 11,500 m, where the temperature is -52^{o}C and the specific heat ratio is k = 1.4. Determine the Mach number at the specified altitude. State whether flow is supersonic or subsonic. **[4]**

B. What are timeline and pathline? Discuss their significance with the help of an example. **[4]**

Q.4) **A.** An inclined manometer is connected between two fluids, one with pressure, P_A and the other with pressure, P_B. The fluid in section A is water (ρ_A = 1000 kg/m^3) and the fluid in section B is oil (ρ_B = 920 kg/m^3). If the manometer fluid is mercury (ρ_{Hg} = 13,560 kg/m^3), calculate the pressure difference between point A and point B. Data: h_1 = 7 cm, h_3 = 3 cm, l_2 = 5 cm, $\theta = 30^\circ$ **[7]**



B. What should be the gap "a" between two infinite vertical parallel plates so that the height due to capillary action of water exposed to air is same as that in a circular tube of diameter "D". **[5]**

Q.5) The velocity distribution in a two-dimensional steady flow field in the *xy* plane is $\vec{V} = (Ax - B)\hat{i} + (C - Ay)\hat{j}$, where A = 1 s^{-1}, B = 3 m.s^{-1}, and C = 5 m.s^{-1}; the coordinates are measured in meters, and the body force distribution is $\vec{g} = -g\hat{k}$ **[8]**

(a) Does the velocity field represent the flow of an incompressible fluid?
(b) Find the stagnation point of the flow field.
(c) Obtain an expression for the pressure gradient in the flow field.

Q.6) **A.** What do you understand by NPSHA and what is its significance? **[6]**
B. Derive an expression for the NPSHA and label all the parameters used in the expression on an appropriate schematic. **[8]**
C. How to increase the NPSHA for systems with low NPSHA (i.e., NPSHA<NPSHR)? **[3]**

Q.7) Draw a neat and labelled schematic of pressure drop and bed height versus superficial velocity for a bed of solids in fluidization. Discuss the schematic in detail. **[15]**

(OPEN BOOK; Minimum: 45 Minutes)

Q.1) In order to increase the gas distribution through a packed bed, an engineer proposes an innovative design of the gas distributor. He uses a perforated pipe of 0.4 m diameter through which a gas flows steadily. The pressure drop between inlet and outlet of the pipe is 100 kPa and density drop is 50%. The gas flows through the perforated wall at the rate of 15 kg/s in a direction normal to the pipe axis. If at the pipe inlet the density is 5 kg/m^3, and the mean velocity is 180 m/s, then what would be the axial force of the gas on the pipe? **[10]**

Q.2) SAE 30 Oil at 60^{o}C flows through a 25 m long horizontal drawn-tubing pipe of 4 cm diameter, at a flow rate of 3 Liters/s. By what percentage ratio will the energy loss increase if the same flow rate is maintained while the pipe diameter is reduced to 1 cm? **[20]**

--------- THE END ----------