Roll Number: ____________________

Thapar University, Patiala

Department of Chemical/Civil Engineering

B. E. (Second Year): Semester-III End Semester Examination, Dec, 2016	Course Code: UES-011 Course Name: Thermo-Fluids
Time: 3 Hours, M. Marks: 100	Name of Faculty: GCH/RM/HPB/RKG/SJS/TK/RB/SMB/JPK/NS/PMS

Note: **Attempt all questions, and all parts of a question in a sequence.**
Attempt the paper as per the portion you have studied AFTER mid semester examination i.e. Thermodynamics (Part A) OR Fluid Mechanics (Part B). All the figures related to PART A as well as PART B are given at the end.
Write at the top of your answer sheet either Thermodynamics or Fluid Mechanics.
Assume missing data, if any, suitably.

PART A
(THERMODYNAMICS)

Q1. (a) Determine the pressure exerted on the surface of a submarine cruising 53 m below the free surface of the sea. Assume that the barometric pressure is 101 kPa and the specific gravity of sea water is 1.03. Density of water =997 kg/m^3. **3**

(b) A manometer containing oil (ρ = 850 kg/m^3) is attached to a tank filled with air. If the oil level difference between the two columns is 80 cm and the atmospheric pressure is 98 kPa, determine the absolute pressure of the air in the tank. **4**

(c) Define Closed system, open system and isolated system. **3**

(d) Fill out the following table using steam tables. **6**

S. No.	Pressure (MPa)	Specific Vol. (m^3/kg)	Temp (^{0}C)	Quality	State
1	1.2			0.75	
2	6		300		
3	0.002		110		

Q.2 (a) Water at 200 kPa with a quality of 25% has its temperature raised 20^{0}C in a constant pressure process. What is the new quality and specific volume? **3**

(b) One kg of water fills a 0.1546 m^3 weighted piston cylinder device at a temperature of 350^{o}C. The piston cylinder device is now cooled under constant pressure until its temperature is 100^{o}C. Determine the final pressure, in MPa, and the volume, in m^3. **6**

(c) A piston cylinder device initially contains air at 150 kPa and 27^{0}C. At this state the piston is resting on a pair of stops and the enclosed volume is 400L. The mass of the piston is such that a 350 kPa pressure is required to move it. The air is now heated until its volume has doubled. Determine (a) the final temperature, (b) the work done by the air, and (c) the total heat transferred to the air. **7**

Q.3 (a) A thermodynamic system undergoes a cycle composed of a series of three processes for which Q1 = +10 kJ, Q2 = +30 kJ, Q3 = -5 kJ. For the first process, ΔE = +20kJ and for the third process, ΔE = +20kJ. What is the work in the second process, and the net work output of the cycle? **8**

(b) Steam flows steadily through an adiabatic turbine. The inlet conditions of the steam are 4 MPa, 500^0C, and 80 m/s, and the exit conditions are 30 kPa, 92 percent quality, and 50 m/s. The mass flow rate of the steam is 12 kg/s. Determine (*a*) the change in kinetic energy, (*b*) the power output, and (*c*) the turbine inlet area. **8**

Q.4 (a) Air flows through a nozzle as shown in **Figure 1**. The inlet conditions are: pressure is 7 kPa, temperature is 420 °C, velocity of air is 400 m/s, and the diameter of the nozzle is 200 mm. The nozzle exit diameter is adjusted such that the existing velocity should be 700 m/s. Calculate (a) the exit temperature, (b) the mass flux (mass flow rate), and (c) the exit diameter. Assume an adiabatic quasi-equilibrium flow. Take c_p = 1000 J/(kg-K); γ = 1.4 and R = 287 J/(kg-K). Comment on the equipment is either nozzle or diffuser. **8**

(b) A heat pump is to be used for heating a house in winter. The house is to be maintained at 26^0C at all times. When the temperature outdoors drops to -4^0C, the heat losses from the house are estimated to be 70,000 kJ/h. Determine the minimum power required to run this heat pump if heat is extracted from (*a*) the outdoor air at -4^0C and (*b*) the well water at 10^0C. **8**

Q.5 (a) An automobile engine produces 136 hp on the output shaft with a thermal efficiency of 30%. The fuel it burns gives 35000 kJ/kg as energy release. Find the total rate of energy rejected to the ambient and the rate of fuel consumption in kg/s. 1 hp = 0.7355 kW. **5**

(b) A reversible heat engine operating between two thermal reservoirs at 800^0C and 30^0C drives a reversible refrigerator which refrigerates a space at -15^0C and delivers heat to a thermal reservoir at 30^0C. The heat input to the heat engine is 1900 kJ and there is a net work output from the combined plant (heat engine & refrigerator) of 290 kJ. Determine the heat transfer to the refrigerant and the total heat transfer to the 30^0C thermal reservoir? **11**

Q.6 (a) Two large fixed parallel horizontal planes are 12 mm apart. The space between the planes is filled with an oil of viscosity 0.9 N.s/m^2. A flat thin plate of 0.2 m^2 area moves through the oil at a constant velocity of 0.25 m/s. Calculate the drag force for the following cases: **4**

i. Plate is equidistant from both the planes.
ii. Plate is at a distance of 3.5 mm from the lower plane.

(b) A horizontal pipe 40 m long is connected to a water tank at one end and discharges freely into atmosphere at the other end. For the first 25 m of length of pipe from the tank, the pipe is 150 mm diameter and then its diameter is suddenly enlarged to 300 mm for the remaining 15 m length of pipe. The height of water level in the tank is 8 m above the centre of pipe. Considering all losses of head, calculate the rate of flow. Also, plot HGL and TEL. The co-efficient of friction for both sections of pipe is 0.01. **6**

(c) In **Figure 3**, a turbine is shown with an inlet pipe and a draft tube. If efficiency of turbine is 80% and discharge is 1000 lps, find (**i**) power developed by the turbine and (**ii**) reading of gauge **G**. **10**

PART B
(FLUID MECHANICS)

Q1. (a) Explain the phenomenon of capillarity. 3

(b) Derive the 3D equation of pressure variation in a static fluid mass. Hence, deduce the hydrostatic law of pressure variation. 4

(c) Define: Steady flow, uniform flow, laminar flow and turbulent flow. 4

(d) Derive an expression for continuity equation for steady and incompressible flow through a stream tube. 4

(e) A horizontal circular pipe of diameter $\mathbf{d_1}$ has a sudden expansion to a diameter $\mathbf{d_2}$. Derive an expression for head loss due to this sudden expansion. 5

Q2. (a) Two large fixed parallel horizontal planes are 12 mm apart. The space between the planes is filled with an oil of viscosity 0.9 $N.s/m^2$. A flat thin plate of 0.2 m^2 area moves through the oil at a constant velocity of 0.25 m/s. Calculate the drag force for the following cases: 4

i. Plate is equidistant from both the planes.

ii. Plate is at a distance of 3.5 mm from the lower plane.

(b) The water in a tank is pressurized by air, and pressure is measured by a multifluid manometer **(Figure 2)**. Determine the pressure of air in the tank if $\mathbf{h_1}$ =0.2 m, $\mathbf{h_2}$ = 0.3 m, and $\mathbf{h_3}$ = 0.46 m. Take the densities of water, oil and mercury as 1000 kg/m^3, 850 kg/m^3 and 13600 kg/m^3, respectively. 6

(c) An inclined rectangular sluice gate **AB**, 4 m wide and 1 m deep is installed to control the flow of water. The upper end **A** of the gate is hinged and lies at a vertical distance of 2 m from the free surface of water. The inclination of gate with horizontal is 45^0. Find the total pressure on the gate and its location. Also, determine the normal force to be applied at lower end **B** to open it. 10

Q3. (a) In **Figure 3**, a turbine is shown with an inlet pipe and a draft tube. If efficiency of turbine is 80% and discharge is 1000 litres per second (lps), find **(i)** power developed by the turbine and **(ii)** reading of gauge **G**. 10

(b) An orifice meter with orifice diameter 150 mm is inserted in a pipe of 300 mm diameter. The water pressure on the upstream and downstream sides of the meter are 147 kPa and 98.1 kPa, respectively. Find discharge, if discharge coefficient is 0.60. 4

(c) The angle of a reducing bend is 60^0 in the anticlockwise direction. Its initial diameter is 300 mm and final diameter is 150 mm and is fitted in a horizontal pipeline, carrying a discharge of 360 lps. The pressure at the commencement of the bend is 2.943 bar. The friction loss in the bend may be assumed as 10% of velocity head at exit of bend. Determine the magnitude and direction of force exerted on the reducing bend. 6

Q4. (a) Crude oil of viscosity 1.5 poise and relative density 0.90 flows through a 20 mm diameter vertical pipe. The pressure gauges fixed 20 m apart read 600 kPa and 200 kPa as shown in **Figure 4.** Find the direction and flow rate through pipe. Assume laminar flow in the pipe. **8**

(b) A horizontal pipe 40 m long is connected to a water tank at one end and discharges freely into atmosphere at the other end. For the first 25 m of length of pipe from the tank, the pipe is 150 mm diameter and then its diameter is suddenly enlarged to 300 mm for the remaining 15 m length of pipe. The height of water level in the tank is 8 m above the centre of pipe. Considering all losses of head, calculate the rate of flow. Also, plot HGL and TEL. The co-efficient of friction for both sections of pipe is 0.01. 6

(c) The velocity distribution in the boundary layer of a flow is given by $(u/U_o) = (y/\delta)$, where u is the velocity at a distance y from the plate and $u = U_o$ at $y = \delta$, δ being the boundary layer thickness. Determine the displacement thickness, the momentum thickness and the energy thickness. 6

Q5. (a) A piston cylinder device initially contains air at 150 kPa and 27°C. At this state the piston is resting on a pair of stops and the enclosed volume is 400L. The mass of the piston is such that a 350 kPa pressure is required to move it. The air is now heated until its volume has doubled. Determine (a) the final temperature, (b) the work done by the air, and (c) the total heat transferred to the air. **(7)**

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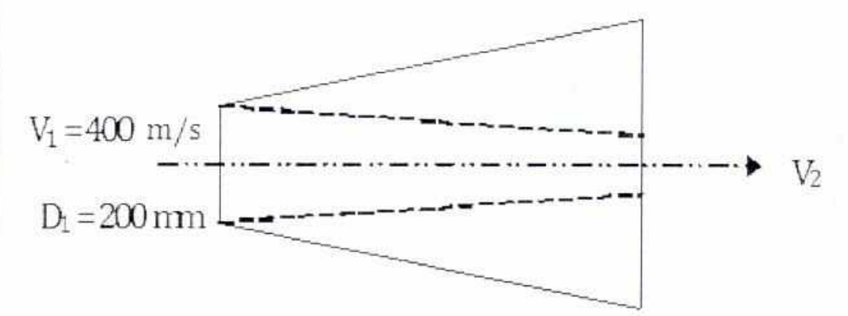

Figure 1

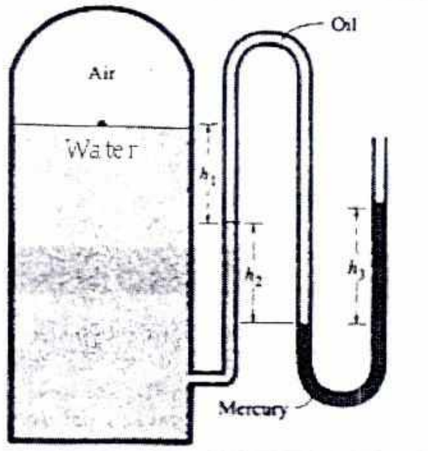

Figure 2

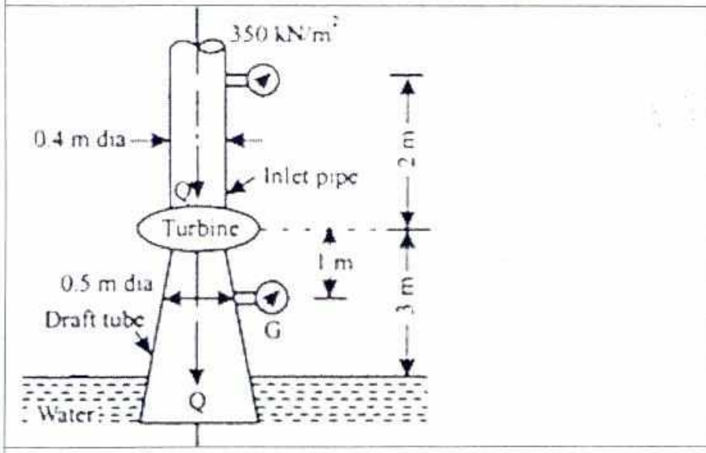

Figure 3

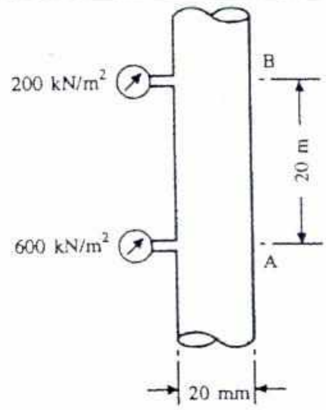

Figure 4