Roll Number:_____

Thapar University, Patiala
Department of Chemical/Civil Engineering
END SEMESTER EXAMINATION

B. E. (Second Year): Semester-IV (2016/17)	Course Code: UES011
(COE/COEM/CAG/CML/ECE/ECEM/SEM/ECM)	Course Name: Thermo-Fluids
May, 2017	
Time: 3 Hours, M. Marks: 100	Name Of Faculty: VKS, SKA, RKA, VKB, AC, SKS, RGU, DNR, RB, TK

Note: *Attempt all questions, and all parts of a question at same place.*
Attempt the paper as per the portion you have studied AFTER mid semester examination i.e. Thermodynamics (Part A)/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 tutorial group and either Thermodynamics or Fluid Mechanics (as per what you studied after mid semester examination).
Assume missing data, if any, suitably.
Use of steam table is allowed.

PART A
(THERMODYNAMICS)

Q.1 (a) A system has followed two different thermodynamic cycles (1a2b1 and 1a2c1) as per given in Figure 1. Prove that internal energy change in process 2b1 and process 2c1 will be equal. (04)

Q.1 (b) A vessel of cylindrical shape is 50 cm in diameter and 75 cm high. It contains 4 kg of a gas. The pressure measured with manometer indicates 620 mm of Hg above atmosphere when barometer reads 760 mm of Hg. Determine: (04)
(i) The absolute pressure of the gas in the vessel
(ii) Specific volume and density of the gas
(Given: Density of Hg = 13.6 kg/m³)

Q.1 (c) 0.2 m³ of air at 400 kPa and 130°C is contained in a system. A reversible adiabatic expansion takes place till the pressure falls to 102 kPa. Air is then heated at constant pressure till enthalpy increases by 72.5 kJ. Calculate total work done for above two processes.
(Given: C_P = 1 kJ/kg.K, C_V = 0.714 kJ/kg.K) (08)

Q.2 (a) The pressure gauge on a 2.5 m³ oxygen tank reads 500 kPa. Determine the mass of oxygen in the tank if the temperature is 28°C and the atmospheric pressure is 97 kPa. Data: molar mass of O_2 is 32 g/mol. (R = 8.314 J/mol-K) (04)

Q.2 (b) A 1.8 m³ rigid tank contains steam at 220°C. One-third of the volume is in the liquid phase and the rest is in the vapor form. Determine the quality and density of the saturated mixture. (05)

Q.2 (c) A piston–cylinder device contains 0.8 kg of steam at 300°C and 1 MPa. Steam is cooled at constant pressure until one-half of the mass condenses.
(i) Show the process on a T-v diagram.
(ii) Find the final temperature.
(iii) Determine the volume change. (07)

Q.3 (a) A piston cylinder contains pure oxygen (γ = 1.4) at ambient conditions 20°C, 100 kPa. The piston is moved to a volume that is 7 times smaller than

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the initial volume in a polytropic process with exponent n = 1.25. Use constant heat capacity to find the final pressure and temperature, the specific work and the specific heat transfer.
(Given: R = 8.314 KJ/Kg-mol.K)   (08)

Q.3 (b) A piston/cylinder contains 1 kg of water at 20°C with a volume of 0.1 m³. The mass of the piston is such that a water pressure of 400 kPa will float it. To what temperature should the water be heated to lift the piston? If it is heated to saturated vapor, find the final volume and the work.   (08)

Q.4 (a) A turbine has 0.05 kg/s helium entering at 1000 kPa, 550 K and it leaves at 250 kPa, 300 K. The power output on the shaft is measured to 55 kW. Find the rate and direction of heat transfer neglecting the changes in macroscopic kinetic and potential energies. If one consider the changes in macroscopic kinetic and potential energies in this process by assuming that the gas enters the turbine with a velocity of 10 m/s at an elevation of 5m above the ground level and leaves the turbine at a velocity of 40m/s at an elevation of 10m above the ground level, then estimate and compare the rate of heat transfer for this case with the previous cases. Assume specific heat capacity, C_p of helium as 5.193kJ/kg-K and acceleration due to gravity, g as 9.81 m/s².   (08)

Q.4 (b) The adiabatic compressor of a device receives air from the ambient at 95 kPa, 20°C, with a very low velocity. At the compressor discharge, air exits at 1.52 MPa, 430°C, with velocity of 90 m/s. The power input to the compressor is 5000 kW. Determine the mass flow rate of air through the unit. Assume specific heat capacity, C_p of air as 1.004 kJ/kg-K.   (08)

Q.5 (a) An engine is to be designed to produce 0.735 kW by taking continuously 6000 kJ/h from heat source which is at 505K. The heat sink is atmosphere i.e. sink temperature is atmospheric. The atmospheric temperature varies from 38°C in summer to 0°C in winter. Comment on the performance of the engine.   (04)

Q.5 (b) A Carnot heat engine works between two thermal reservoirs. A and B. A is at constant temperature 600°C and B is at 250°C. Half of the power developed by the Carnot engine is used to drive a heat pump which receives heat from thermal reservoir B and rejects heat to a thermal reservoir C which is at temperature 400°C. Calculate the heat rejected to thermal reservoir C by the heat pump as a percentage of heat from thermal reservoir A to the Carnot engine. Also calculate the heat rejected per hour to thermal reservoir C if 480 kW is net power output of combined device (heat pump and heat engine).   (12)

Q.6 (a) Show that the head loss due to sudden contraction in a pipe is proportional to velocity head of contracted pipe.   (06)

Q.6 (b) A venturimeter has its axis vertical. The inlet and throat diameters of venturimeter are 150 mm and 75 mm respectively. The throat is 225 mm above the inlet. Petrol of specific gravity 0.78 flows up through the venturimeter at a rate of 0.029 m³/s. Find the pressure difference between

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the inlet and throat. Coefficient of discharge of venturimeter is 0.96. (06)

Q.6(c) A vertical gap 22 mm wide and of infinite extent contains oil of specific gravity 0.90 and viscosity 20 Poise. A metallic plate 1.2 ×1.2 × 0.002 m and weighing 40 N is to be lifted through the gap with a constant velocity of 0.15 m/s. If plate is placed in the middle of gap, calculate the viscous resistance to be overcome by the plate and the force required to lift the (08) plate.

Part B
FLUID MECHANICS

Q.1 (a) A vertical gap 22 mm wide and of infinite extent contains oil of specific gravity 0.90 and viscosity 20 Poise. A metallic plate 1.2 ×1.2 × 0.002 m and weighing 40 N is to be lifted through the gap with a constant velocity of 0.15 m/s. If plate is placed in the middle of gap, calculate the viscous (08) resistance to be overcome by the plate and the force required to lift the plate.

(b) A typical differential manometer is attached to two sections A and B in a horizontal pipe through which water is flowing at a steady rate as shown in Figure 2. The deflection of mercury in the manometer is 0.6 m. Calculate the difference of pressure between section A and B. (10)

Q.2 (a) Find the acceleration of a fluid particle at a point (2, 4, -4) at time t= 3 for (10) the velocity field $V = (4+xy+2t)\hat{i} + (6x^3)\hat{j} + (3xt^2 + z)\hat{k}$

(b) A venturimeter has its axis vertical. The inlet and throat diameters of venturimeter are 150 mm and 75 mm respectively. The throat is 225 mm above the inlet. Petrol of specific gravity 0.78 flows up through the venturimeter at a rate of 0.029 m³/s. Find the pressure difference between the inlet and throat. Coefficient of discharge of venturimeter is 0.96. (6)

Q.3 (a) Water flows through a 0.9 m diameter pipe at the end of which there is a reducer connecting to a 0.6 m diameter pipe. The axis of the pipe is horizontal. If the gauge pressure at the entrance to the reducer is 412.02 kN/m² and the velocity is 2 m/s, determine the resultant thrust on the (10) reducer assuming frictional loss of head in the reducer is 1.5 m.

(b) Determine the displacement thickness and momentum thickness for the following velocity distribution

$$\frac{u}{U} = 2\frac{y}{\delta} - \left(\frac{y}{\delta}\right)^2$$

Where δ is boundary layer thickness and U is free stream velocity. (10)

Q.4 (a) Show that the centre of pressure of any object submerged vertically in a (10) static mass of liquid always lies below its centroid.

(b) Bernoulli's equation derived from Euler's equation is for a steady incompressible, inviscid and irrotational flow. Comment on the statement with justification. (10)

(c) Show that the head loss due to sudden contraction in a pipe is proportional to velocity head of contracted pipe. (06)

Q.5 (a) An engine is to be designed to produce 0.735 kW by taking continuously 6000 kJ/h from heat source which is at 505K. The heat sink is atmosphere i.e. sink temperature is atmospheric. The atmospheric temperature varies from 38°C in summer to 0°C in winter. Comment on the performance of the engine. (04)

(b) A turbine has 0.05 kg/s helium entering at 1000 kPa, 550 K and it leaves at 250 kPa, 300 K. The power output on the shaft is measured to 55 kW. Find the rate and direction of heat transfer neglecting the changes in macroscopic kinetic and potential energies. If one consider the changes in macroscopic kinetic and potential energies in this process by assuming that the gas enters the turbine with a velocity of 10 m/s at an elevation of 5m above the ground level and leaves the turbine at a velocity of 40m/s at an elevation of 10m above the ground level, then estimate and compare the rate of heat transfer for this case with the previous cases. Assume specific heat capacity, C_p of helium as 5.193kJ/kg-K and acceleration due to gravity, g as 9.81 m/s². (08)

(c) A piston/cylinder contains 1 kg of water at 20°C with a volume of 0.1 m³. The mass of the piston is such that a water pressure of 400 kPa will float it. To what temperature should the water be heated to lift the piston? If it is heated to saturated vapor, find the final volume and the work. (08)
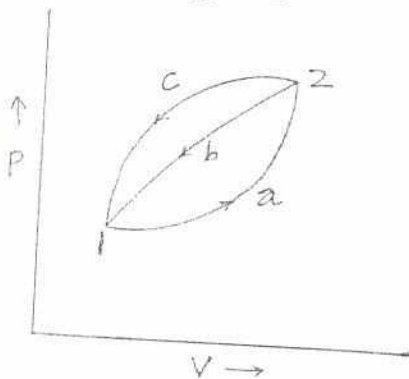
Figure 1

Figure 2