BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: BTECH **SEMESTER : V**
BRANCH: MECHANICAL **SESSION : MO/2022**

SUBJECT: ME331 THERMO-FLUID ENGINEERING

TIME: 3:00 Hours **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

Q.1(a) Define the final form of Reynold Transport Theorem and describe the significance of each term. [2]

Q.1(b) A two dimensional flow is described in the Lagrangian system as [4]

$$x = x_0 e^{-kt} + y_0(1 - e^{-2kt}) \text{ and } y = y_0 e^{kt}$$

Find (i) the equation of path line of the particle and (ii) the velocity components in Eulerian system.

Q.1(c) A velocity field is given by $\vec{V} = Ax\hat{i} - Ay\hat{j}$; x and y in meters. A= 0.3 s^{-1}. [4]

Find out (i) equation of the streamlines in the xy plane and (ii) position at t=6s of particle located at (2, 8) at t=0

Q.2(a) Write the Bernoulli equation and its assumptions. [2]

Q.2(b) Consider a flow field represented by the stream function $\psi = -\frac{A}{2\pi\left(x^2+y^2\right)}$, where A = constant. Is this a possible two-dimensional incompressible flow? Is the flow irrotational? [3]

Q.2(c) The x component of velocity in a steady, incompressible flow field in the xy plane is u = $A(x^5 - 10x^3y^2 + 5xy^4)$, where A = 2 m^{-4} . s^{-1} and x is measured in meters. [5]

(i) Find the simplest y component of velocity for this flow field.
(ii) Evaluate the acceleration of a fluid particle at point (x, y)=(1, 3).

Q.3(a) Specify the X, Y and Z momentum equations in a cartesian coordinate. [2]

Q.3(b) Consider a fully developed laminar flow through a straight tube of radius R of circular cross-section. Consider the z-axis along the flow direction and the r-axis normal to it. [8]
Find out the following with proper valid assumptions:

i. continuity equation
ii. velocity profile across the tube cross-section
iii. shear stress profile across the tube cross-section
iv. discharge through the pipe

Q.4(a) What is reversible work and irreversibility of a system? [2]

Q.4(b) A house that is losing heat at a rate of 80,000 kJ/h when the outside temperature drops to 15°C is to be heated by electric resistance heaters. If the house is to be maintained at 22°C at all times, determine the reversible work input for this process and the irreversibility. [3]

Q.4(c) Steam enters a turbine at 12 MPa, 550°C, and 60 m/s and leaves at 20 kPa and 130 m/s. The turbine is not adequately insulated and it estimated that heat is lost from the turbine at a rate of 150 kW. The power output of the turbine is 2.5 MW. Assuming the surroundings to be at 25°C, determine (*a*) the reversible power output of the turbine, (*b*) the exergy destroyed within the turbine, and (*c*) the second-law efficiency of the turbine. [5]

Given: h_1 = 3481.7 kJ/kg and s_1 = 6.6554 kJ/kg K at P_1 =12 MPa, T_1 = 550°C
h_2 = 2491.1 kJ/kg and s_2 = 7.5535 kJ/kg K at P_2 =20 kPa
at dead state h_0 = 104.83 kJ/kg at T_0 = 25°C

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Q.5(a) How and why is the stagnation enthalpy h_0 defined? How does it differ from ordinary (static) enthalpy? [2]

Q.5(b) What is the effect of back pressure on the development of normal shock in a convergent-divergent nozzle? [3]

Q.5(c) Carbon dioxide enters an adiabatic nozzle at 1200 K with a velocity of 50 m/s and leaves at 400 K. Assuming constant specific heats at room temperature, determine the Mach number (*a*) at the inlet and (*b*) at the exit of the nozzle. The gas constant of carbon dioxide is R = 0.1889 kJ/kg·K. Its constant pressure specific heat and specific heat ratio at room temperature are c_p = 0.8439 kJ/kg·K and k = 1.288. [5]

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