Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

ME – SEMESTER-1 (OLD) EXAMINATION – WINTER 2016

Subject Code: 711101N Date:17/11/2016

Subject Name: Advanced Thermodynamics and Heat Transfer

Time:10:30 Am to 1:00 Pm Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Evaluate entropy balance for a closed system and explain each term with its significance. **07**

(b) Write down the expressions for the physical laws that govern each mode of heat transfer, and identify the variables involved in each relation. **07**

Q.2 **(a)** Derive an expression for availability in steady flow systems. **07**

(b) A piston–cylinder device contains 0.05 kg of steam at 1 MPa and 300°C. Steam now expands to a final state of 200 kPa and 150°C, doing work. Heat losses from the system to the surroundings are estimated to be 2 kJ during this process. Assuming the surroundings to be at T_0 = 25°C and P_0 = 100 kPa, Determine (a) the exergy of the steam at the initial and the final states, (b) the exergy change of the steam, (c) the exergy destroyed, and (d) the second-law efficiency for the process. **07**

OR

(b) Derive the following Tds equation **07**

$$Tds = c_v \left(\frac{\partial T}{\partial p}\right)_v dP + c_p \left(\frac{\partial T}{\partial v}\right)_p dv$$

and also show that this may be written as:

$$Tds = \frac{c_v}{\beta} KdP + \frac{c_p}{\beta v} dv$$

Q.3 **(a)** Derive the governing differential equation for temperature distribution of constant area extended surface in the following form: **07**

$$\frac{d^2\theta}{dx^2} = m^2\theta, Where\ m = \sqrt{\frac{hP}{kA_c}}$$

(b) An egg with mean diameter of 4-cm is initially at a uniform temperature of 25°C dropped into boiling water pan for 4 minutes and found to be boiled to the consumer's taste. For how long should a similar egg for same consumer be boiled when taken from refrigerator at 5°C? Use lumped parameter theory and presume the following properties for egg: h =125 W/m2-°C; k= 12 W/m- °C; c = 2 kJ/kg K and ρ = 1250 kg/m^3 **07**

OR

Q.3 **(a)** Prove that the temperature of a body at any time τ during Newtonian heating or cooling is given by the relation **07**

$$\frac{t-t_a}{t_i-t_a} = \exp[-B_i F_o],$$

Where B_i and F_o are the Biot and Fourier modulus respectively; t_a is ambient temperature and t_i is the initial temperature of the body.

(b) Discuss the numerical formulation and solution of two-dimensional steady heat conduction in rectangular coordinates using the finite difference method. **07**

Q.4 **(a)** Define Lambert's cosine law of radiation and prove that the intensity of radiation is always constant at any angle of emission for a diffused surface. **07**

(b) Define the properties emissivity and absorptivity. When are these two properties equal to each other? **07**

OR

Q.4 **(a)** Explain Hottel's crossed string method for estimating shape factor for infinitely long surfaces. Derive the expression for F12 in terms of areas and lengths of surfaces. **07**

(b) Consider the 5-m × 5-m × 5-m cubical furnace, whose surfaces closely approximate black surfaces. The base, top, and side surfaces of the furnace are maintained at uniform temperatures of 800 K, 1500 K, and 500 K, respectively. Determine (a) the net rate of radiation heat transfer between the base and the side surfaces, (b) the net rate of radiation heat transfer between the base and the top surface, and (c) the net radiation heat transfer from the base surface. **07**

Q.5 **(a)** Derive the following two dimensional force or momentum equation of the boundary layer with constant properties **07**

$$u\frac{\partial u}{\partial x} + v\frac{du}{dy} = \nu\frac{d^2u}{dy^2}$$

(b) What is the physical significance of Grashof number with reference to heat transfer by natural convection? What is Rayleigh number? **07**

OR

Q.5 **(a)** Engine oil at 60°C flows over the upper surface of a 5-m-long flat plate whose temperature is 20°C with a velocity of 2 m/s. Determine the total drag force and the rate of heat transfer per unit width of the entire plate. The properties of engine oil at the film temperature of T_f = 40°C are ρ = 876 kg/m^3 Pr = 2870
k = 0.144 W/m°C $\nu = 242\times10^{-6}$ m2/s **07**

(b) How is Reynolds analogy expressed? What is the value of it? What are its limitations? **07**

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