Seat No.: _____ Enrolment No._____

# GUJARAT TECHNOLOGICAL UNIVERSITY

**ME - SEMESTER– I (OLD course)• EXAMINATION – SUMMER 2015**

**Subject Code: 711101** **Date: 11/05/2015**

**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.**

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|---|---|---|---|
| **Q.1** | **(a)** | The thermal conductivity of a material varies linearly with temperature; derive the one- dimensional, steady state heat conduction equation with internal heat generation by writing the energy balance for a differential volume element in cylindrical coordinate system. | **07** |
| | **(b)** | What do you mean by critical radius of insulation? Deduce the expression for it. Explain it concept with help of material and surface resistances. | **07** |
| **Q.2** | **(a)** | Derive expressions for temperature distribution and heat dissipation in a straight fin of rectangular profile of the following cases: (i) Infinitely long fin; (ii) fin losing heat at the tip. | **07** |
| | **(b)** | Define Following:<br>(i) Critical Reynolds Number (ii) Prandtl Number (iii) Grashof Number (iv) Nusselt Number (v) Stanton Number (vi) Peclet Number (vii) Graetz Number. | **07** |
| | | **OR** | |
| | **(b)** | The inside and outside surfaces of a hollow sphere of radii $r_1$ and $r_2$ are maintained at constant temperatures $T_1$ and $T_2$ respectively. The thermal conductivity of insulating material varies with temperature as $k = k_o\left(1+\alpha T+\beta T^2\right)$, where $k_o$ is constant. Derive an expression for heat flow through the sphere. | **07** |
| **Q.3** | **(a)** | Prove that the temperature distribution in a body at time ***t*** during a Newtonian heating or cooling is given by: $\frac{T-T_\infty}{T_i-T_\infty}=e^{-Bi\,Fo}$ | **07** |
| | **(b)** | State and prove Kirchhoffôs law of radiation. | **07** |
| | | **OR** | |
| **Q.3** | **(a)** | Show by dimensional analysis that for forced convection heat transfer, Nusselt number is a function of Reynolds number and Prandtl number. | **07** |
| | **(b)** | Derive the integral momentum equation for the boundary layer over a flat plate. | **07** |
| **Q.4** | **(a)** | What is Wienôs displacement law? Derive an expression for its relation. What is a diffuse body? | **07** |
| | **(b)** | Answer in brief:<br>(i) What are radiation shape factors and why are they used?<br>(ii) What is the radiation shield? Where is it used? | **07** |
| | | **OR** | |
| **Q.4** | **(a)** | Give and explain the following statements of second law of thermodynamic (i) Clausius statement (ii) Kelvin ï Planck statement. Prove that they are equivalent. | **07** |

**(b)** Using Maxwellôs relation $\left(\frac{\partial p}{\partial T}\right)_v = \left(\frac{\partial s}{\partial v}\right)_T$ derive Clapeyron equation $\frac{dp}{dT} = \frac{h_{fg}}{T\left(v_g - v_f\right)}$ and explain the utility of this equation in thermodynamics. **07**

**Q.5** **(a)** Explain calculation of available energy referred to (i) an infinite thermal reservoir and (ii) a finite thermal reservoir. **07**

**(b)** Derive the three $T.ds$ equations as stated below: **07**

$$(i)\ Tds = C_v dT + T\left(\frac{\partial p}{\partial T}\right)_v dv;\ (ii)\ Tds = C_p dT - T\left(\frac{\partial v}{\partial T}\right)_p dp$$

$$and\ Tds = C_v\left(\frac{\partial T}{\partial p}\right)_v dp + C_p\left(\frac{\partial T}{\partial v}\right)_p dv$$

**OR**

**Q.5** **(a)** What do you understand by entropy transfer? Why is entropy transfer associated with heat transfer and not with work transfer? **07**

**(b)** Differentiate clearly between the following: **07**

(i) Macroscopic and microscopic views,

(ii) Diathermal wall and adiabatic wall.

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