

GUJARAT TECHNOLOGICAL UNIVERSITY
BE - SEMESTER-VII • EXAMINATION – WINTER 2013

Subject Code: 170102**Date: 05-12-2013****Subject Name: Theory of Heat Transfer****Time: 10:30 TO 01:00****Total Marks: 70****Instructions:**

1. Attempt all questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.
4. Tables for properties of air and water are permitted.

- Q.1** (a) Derive general heat conduction equation in Cartesian coordinates **07**
(b) A thermopane window consists of two 5 mm thick glass ($k = 0.78 \text{ W/m-K}$) **07**
sheets separated by 10 mm stagnant air gap ($k = 0.025 \text{ W/m-K}$). The convection
heat transfer coefficient for inner and outside air are $10 \text{ W/m}^2\text{-K}$ and $50 \text{ W/m}^2\text{-K}$, resp. (i) Draw electrical analogy for system (ii) Determine the rate of heat
loss per m^2 of the glass surface for a temperature difference of 60°C between
the inside and outside air. (iii) Compare the result with the heat loss, if the
window had only a single sheet of glass of thickness 5 mm instead of
thermopane (iv) Compare the result with the heat flow, if window has no
stagnant air (i.e., a sheet of glass, 10 mm thick)

- Q.2** (a) Derive equations of temperature distribution and heat dissipation for fin non- **07**
insulated at tip.
(b) An aluminium alloy fin ($k = 43 \text{ W/m-K}$), 3.50 mm thick and 2.5 cm long **07**
protrudes from a wall. The base is at 420°C and ambient air temperature is 30°C . The heat transfer coefficient of $11 \text{ W/m}^2\text{-K}$. Find the heat loss and fin
efficiency, if the heat loss from fin tip is negligible.

OR

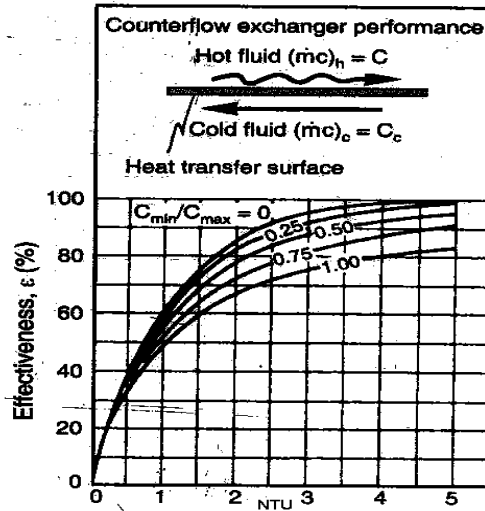
- (b) What should be thickness of insulation on a small diameter wire and a steam **07**
pipe? Explain its physical significance in both the cases & derive an expression
for the same.
- Q.3** (a) Define Re, Nu, Pr. Explain their importance in convection heat transfer. **07**
(b) Air at 20°C and atmospheric pressure is flowing with a velocity of 3 m/s along **07**
the length of a flat plate, maintained at 60°C . Calculate (i) hydrodynamic
boundary layer thickness at 20 cm and 40 cm from the leading edge, by the
approximate method (ii) mass entrainment rate between these two sections
assuming a cubic velocity profile, and (iii) heat transferred from the first 40 cm
of the plate.

OR

- Q.3** (a) Explain lumped heat capacity method and state its assumptions. **07**
(b) A titanium alloy blade of an axial compressor for which $k = 25 \text{ W/m-K}$, $\rho =$ **07**
 4500 kg/m^3 and $C_p = 520 \text{ J/kg-K}$ is initially at 60°C . The effective thickness
of the blade is 10 mm and it is exposed to gas stream at 600°C , the blade
experiences a heat transfer coefficient of $500 \text{ W/m}^2\text{-K}$. Estimate the
temperature of blade after 1, 5, 20 and 100 seconds.

- Q.4** (a) How are the heat exchangers classified ? **07**

- (b) A counter flow heat exchanger is used to heat air entering at 400°C with a flow rate of 6 kg/s by exhaust gas entering 800°C with a flow rate of 4 kg/s . The Overall heat transfer coefficient is $100\text{ W/m}^2\text{-K}$ and the outlet temp. of air is 551.5°C . The specific heat at constant pressure for both air and exhaust gas can be taken as 1100 J/kg-K . Calculate (i) Effectiveness of heat exchanger (ii) Heat transfer area needed, (iii) Number of Transfer units. 07



OR

- Q.4 (a) Write Von-karman integral momentum equation, for the hydrodynamic laminar boundary layer of fluid flowing over stationary plate. Using this equation, derive the expression for hydrodynamic boundary layer thickness considering the cubic velocity profile. 07
- (b) Draw and Explain boiling curve for water. Explain Nucleate boiling. 07
- Q.5 (a) Define and explain Radiation shield and Radiation shape factor 07
- (b) Using dimensional analysis, obtain a general form of equation for Natural Convective heat transfer. 07

OR

- Q.5 (a) State & Explain the Wien Displacement Law. Show that $E_{b\lambda}$ will be maximum when $\lambda_{\max} T = 2900\text{ }\mu\text{k}$ 07
- (b) Two large parallel planes with emissivity 0.6 are at 900 K and 300 K . A radiation shield with one side polished and having emissivity of 0.05, while the emissivity of other side is 0.4 is proposed to be used. Which side of the shield to face the hotter plane, if the temperature of shield is to be kept minimum? Justify your answer. 07
