

GUJARAT TECHNOLOGICAL UNIVERSITY
BE SEM-VI Examination-Nov/Dec-2011

Subject code: 161906**Date: 02/12/2011****Subject Name: Heat and Mass Transfer****Time: 10.30 am -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) What is the difference between the natural and forced convection? **03**
- (b) Explain the following terms **04**
1. Radiation
 2. Thermal resistance
 3. Thermal diffusivity
 4. Thermal conductivity
- (c) A gas turbine blade made of stainless steel ($k = 32 \text{ W/m}^\circ\text{C}$) is 70 mm long, 500 mm^2 cross sectional area and 120 mm perimeter. The temperature of the root of blade is 500°C and it is exposed to the combustion product of the fuel passing from turbine at 830°C . If the film coefficient between the blade and the combustion gases is $300 \text{ W/m}^2\text{C}$,
Determine: (1) The temperature at the middle of blade
(2) The rate of heat flow from the blade **07**
- Q.2**
- (a) Derive general heat conduction equation in spherical co-ordinates **07**
- (b) A furnace wall is made up of three layers of thickness 250 mm, 100 mm and 150 mm with thermal conductivity of 1.65, k and $9.2 \text{ W/m}^\circ\text{C}$ respectively. The inside is exposed to gases at 1250°C with a convection coefficient of $25 \text{ W/m}^2\text{C}$ and the inside surface is at 1100°C , the outside surface is exposed to air at 25°C with convection coefficient of $12 \text{ W/m}^2\text{C}$. Determine:-
(1) The unknown thermal conductivity k
(2) The overall heat transfer coefficient
(3) All Surface temperatures **07**

OR

- (b) Derive an expression for heat dissipation in Rectangular Fin of uniform cross section which is insulated at tip. **07**
- Q.3**
- (a) Derive momentum equation for hydrodynamic boundary layer over a flat plate **07**
- (b) Enumerate the factors on which the rate of emission of radiation by body depends. **03**
- (c) Differentiate between pool boiling and forced convection boiling **04**

OR

- Q.3**
- (a) Define Nusselt number and Prandtl number. **04**
- (b) What is black body? How does it differ from gray body? Give examples of each. **03**

- (c) A steam pipe 8 cm in diameter is covered with 3 cm thick layer of insulation which has a surface emissivity of 0.9. The surface temperature of the insulation is 80°C and the pipe is placed in atmospheric air at 24°C. Considering heat loss by both radiation and natural convection calculate: 07
- (1) The heat loss from the 7 m length of pipe.
- (2) The overall heat transfer coefficient and the heat transfer coefficient due to radiation alone.
- The thermo physical properties of air at mean film temperature of 52°C are as following:
- $\rho = 1.092 \text{ kg/m}^3$, $c_p = 1.007 \text{ kJ/kg}^\circ\text{C}$, $\mu = 19.57 \times 10^{-6} \text{ kg/ms}$,
 $k = 27.81 \times 10^{-3} \text{ W/m}^\circ\text{C}$ (where the notations have their usual meaning.)
 use empirical correlation for horizontal cylinders as $Nu = 0.53(Gr.Pr)^{.25}$
- Q.4** (a) Derive the relationship between the effectiveness and number of transfer units for a counter flow heat exchangers. 07
- (b) A heat exchanger is to be designed to condense 8 kg/sec of an organic liquid ($t_{\text{sat}} = 80^\circ\text{C}$, $h_{fg} = 600 \text{ KJ/kg}$) with cooling water available at 15°C and at a flow rate of 60 kg/sec. The overall heat transfer coefficient is 480 $\text{W/m}^2\text{C}$ calculate: 07
- (a) the number of tube required. The tubes are to be of 25 mm outer diameter, 2 mm thickness and 4.85 m length
- (b) The number of tube passes. The velocity of the cooling water is not to exceed 2 m/sec.
- OR**
- Q.4** (a) Sketch a shell and tube type heat exchanger 04
- (b) Discuss the importance of heat exchangers for industrial use. 03
- (c) Water at the rate of 4 kg/sec is heated from 40°C to 55°C in a shell and tube type heat exchanger. The water is to flow inside tubes of 2 cm diameter with an average velocity of 35 cm/sec. Hot water is available at 100°C and at the rate of 2 kg/sec which is used as the heating medium in shell side. If the length of the tube is of 2 m calculate the number of tube passes, the number of tube per pass and the length of the tubes for one shell pass, assuming $U_o = 1500 \text{ W/m}^2\text{K}$ 07
- Q.5** (a) Define the Fick's first law and second law for diffusion 04
- (b) Define convective mass transfer coefficient and what are its units 03
- (c) The air pressure in a tyre tube of surface area 0.5 m^2 and wall thickness of 0.01 m is approximated to drop from 2 bar to 1.98 bar in period of 6 days. The solubility of air in rubber is 0.07 m^3 of air/ m^3 of rubber at 1 bar. Estimate the diffusivity of air in rubber at operating temperature of 300 K if the volume of air in tube is 0.026 m^3 . 07
- OR**
- Q.5** (a) Enumerate the applications of mass transfer 04
- (b) Define absorptivity, reflectivity and transmissivity with respect to radiation heat transfer 03
- (c) Explain the following in detail: (draw neat sketch if required) 07
1. Film wise and drop wise condensation
2. Fouling factors and overall heat transfer coefficient
