Student Exam No.________________

GANPAT UNIVERSITY

B. Tech. Semester: VI (Mechanical Engineering)

CBSC (New) Regular Examination- May - June 2017

HEAT & MASS TRANSFER (2ME603)

Time: 3 Hours **Total Marks: 60**

Instruction: 1. *Attempt all Question.*
2. *Assume suitable data if missing.*
3. *Use of non-programmable scientific calculator is permitted.*

SECTION - I

Que. – 1 **(A)** What do you understand by Heat Transfer? Explain various Modes of Heat Transfer with Examples. **(5)**

(B) Calculate the rate of heat flow per m^2 through a furnace wall consisting of 200 mm thick inner layer of chrome brick, a center layer of kaolin brick 100 mm thick and an outer layer of masonry brick 100 mm thick, the unit surface conduction at the inner surface is 74 W/m^2 and the outer surface temperature is 70^0C. The temperature of the gas inside the furnace is 1670^0C. What temperatures prevail at the inner and outer surfaces of the center layer? **(5)**
Take: $k_{chrome\ brick}=1.25\ W/m^0C$, $k_{kaolin\ brick}=0.074\ W/m^0C$, $k_{masonry}=0.555\ W/m^0C$

OR

Que. – 1 **(A)** Derive the General Heat Conduction Equation in Cartesian Coordinates. **(5)**

(B) A standard cast iron pipe (inner diameter = 50mm and outer diameter = 55mm) is insulated with 85% magnesium insulation (k=0.02 W/m^0C). The temperature at the interface between the pipe and insulation is 300^0C. The allowable heat loss through the pipe is 600 W/m length of pipe and for the safety, the temperature of the outside surface of insulation must not exceed 100^0C. Determine: **(5)**
(i) Minimum thickness of insulation required
(ii) The temperature of inside surface of the pipe assuming its thermal conductivity 20 W/m^0C

Que. – 2 **(A)** What do you understand by critical thickness of insulation? Derive an expression of critical thickness of insulation for cylinder. **(5)**

(B) Steel ball 50 mm diameter and at 900^0C is placed in still atmosphere of 30^0C. Calculate the initial rate of cooling of the ball in ^0C/min. [neglect internal resistance] **(5)**
Take: $\rho = 7800\ kg/m^3$, c = kJ/kg^0C (for steel), h = 30 W/m^2 0C

OR

Que. – 2 **(A)** Derive an expression for heat dissipation from infinitely long rectangular fins. **(5)**

(B) Pin fins are provided to increase the heat transfer rate from a hot surface, which of the following arrangement will give higher heat transfer rate? **(5)**
(i) 6 fins of 10 cm length (ii) 12 fins of 5 cm length
Take: k(fins material) = 200 W/m^0C, h= 20 $W/m^2\ ^0C$, cross section area = 2 cm^2, Perimeter = 4 cm, fin base temperature = 230^0C, surrounding air temperature = 30^0C

Que. – 3 Attempt any two of the followings

(A) Derive an expression of LMTD for parallel flow heat exchanger. **(5)**

(B) Which is a batter HE? Counter flow, parallel flow or cross flow why? What is difference in NTU & LMTD approach? **(5)**

(C) Two fluids A&B exchange heat in a counter current heat exchanger, fluid A enters at 420^0C and has mass flow rate of 1 kg/s, fluid B enters at 20^0C and has mass flow rate of 1 kg/s. Effectiveness of heat exchanger is 75%. Determine heat transfer rate and exit temperature of fluid B. (5)
Assume specific heat of fluid A & B as 1 kJ/kg-K and 4 kJ/kg-K

SECTION - II

Que. – 4 (A) Derive Von Karman integral momentum equation for hydrodynamics boundary layer. (5)

(B) The velocity distribution in the boundary layer is given by $\frac{u}{U} = \frac{3}{2}\frac{y}{\delta} - \frac{1}{2}\frac{y^2}{\delta^2}$, δ being the boundary layer thickness. Calculate the following (5)
(i) the ratio of displacement thickness to boundary layer thickness
(ii) the ratio of momentum thickness to the boundary layer thickness

OR

Que. – 4 (A) Air at 20^0C and at a pressure of 1 bar is flowing over a flat plate at a velocity of 3 m/s. if the plate is 280 mm wide and at 56^0C. Calculate the following quantities at 280 mm. (5)
(i) Boundary layer thickness
(ii) Local friction coefficient
(iii) Shear stress due to friction
(iv) thermal boundary layer thickness
(v) Rate of heat transfer by convection
Assume following properties:
$\rho = 1.1374$ kg/m^3, k = 0.02732 kJ/m^{0}C, C_p = 1.005 kJ/kg-K, $\upsilon = 16.768 \times 10^{-6}$ m^2/s, Pr = 0.7

(B) A tube 5 m long is maintained at 100^0C by steam jacketing. A fluid through the tube at the rate of 2940 kg/h at 30^0C. The diameter of the tube is 2 cm. Find out average heat transfer coefficient. (5)
Take: $\rho = 850$ kg/m^3, k = 0.12W/m^{0}C, C_p = 2 kJ/kg-K, $\upsilon = 5.1 \times 10^{-6}$ m^2/s,

Que. – 5 (A) An Enclosure is formed by three surfaces. Details of their shape factors, emissivities and temperatures are as follows. (5)

Surface	Shape	Emissivity	Temperature
1	Curved Cylindrical	0.8	500^0C
2	One end closing disc	0.85	400^0C
3	Other end closing disc	0.85	400^0C

Diameters of two closing flat closing discs and interspacing between the two are 250 mm and 100 mm respectively. Shape factor between two identical discs is 0.05. Calculate the net rate of radiant heat flow leaving from surface 1 and reaching to each of the surface 2 and 3.

(B) Two concentrating spheres 210 mm and 300 mm diameters with the space between them evacuated are to be used to sore liquid air (-153^0C) in a room at 27^0C. The surfaces of the spheres are flushed with aluminum (ε = 0.03) and latent heat of vaporization of liquid air is 209.35 kJ/kg. Calculate the rate of evaporation of liquid air. (5)

OR

Que. – 5 (A) Consider two large parallel plates one at 727^0C and ε = 0.8 and other at 227^0C and ε = 0.4. An aluminum radiation shield with an emissivity, ε = 0.05 on both sides is placed between the plates. Calculate the percentage reduction in heat transfer rate between the two plates as a result of shield. (5)

(B) A vertical cylinder 1.5 m high and 180 mm in diameter is maintained at 10^0C in an atmosphere of 20^0C. Calculate heat loss by free convection from the surface of the cylinder. Assume properties of air at mean temperature as $\rho = 1.06\ kg/m^3$, $\upsilon = 18.97 \times 10^{-6}\ m^2/s$, $C_p = 1.004$ kJ/kg-K and $k = 0.1042\ kJ/mh^0C$. (5)

Use following equation for approximate solution: $Nu_L = 0.10\ (Gr.Pr)0.33$

Que. – 6 Attempt any two of the followings

(A) Define the following dimensionless numbers: (5)

(i) Reynolds Number (ii) Prandtle Number (iii) Nusselt Number
(iv) Stantont Number (v) Peclet number

(B) Explain the following terms (5)

(i) Radiosity (ii) Emissivity (iii) Kirchhoff's law
(iv) Stefan-Boltzmann law (v) Wien's law (vi) Irradiation

(C) Explain terms Boiling and condensation. Draw and Explain Boiling Regimes. (5)

END OF PAPER