Seat No:_____

**GanpatUniversity**
**B.Tech. Sem. VI Mechanical Engineering**
**CBCS Regular Examination April- June 2015**
**2ME603 Heat and Mass Transfer**

Time: 3 Hours Total Marks: 70

**Instruction:** 1. Attempt all questions.
2. Allow Air and Water properties table
3. Assume suitable data if necessary

**Section -I**

**Que.1.** **(a)** Derive three dimensional heat conduction equation in Cartesian coordinates **(6)**

**(b)** A composite wall is composed of 1 cm thick iron (k = 60 W/m-K), 4 cm thick fiber glass (k = 0.02 W/m-K) and 0.4 cm thick asbestos sheet (k = 0.2 W/m-K).Determine the overall heat transfer coefficient. What is the heat transfer rate per unit area through the composite wall for a temperature difference of 400°C? Sketch the complete thermal circuit diagram for this problem **(6)**

**OR**

**Que.1.** **(a)** An electric cable 10 mm in diameter is to be insulated with rubber. The insulated cable is exposed to air at $20^0$C. Find the most economical thickness of the rubber insulation from heat transfer point of view assuming the cable surface temperature of $60^0$C in bare as well as in insulation condition. **(8)**
Assume the following data , K(Rubber) = 0.14 W/m.K
hi (H.T.C. on the surface of cable) = 7 W/m.K
Also find the percentage increase in current carrying capacity when economical insulation thickness is provided.

**(b)** Explain briefly concept of critical thickness of insulation **(4)**

**Que.2.** A brass rod in the form of a fin 100 mm long and 5 mm in diameter extends horizontally from a casting which is at 200°C. The air temperature is 20°C and provides a heat transfer coefficient of 30 W/$m^2$-K. What is the heat transfer from the rod? Evaluate the temperature of the rod at 50 mm from the base and at the free tip. **(12)**
Now, if this fin is replaced by two identical fins of 50 mm length. All other parameters and dimensions remain the same. What is the heat transfer from this combination? Evaluate the temperature of the fin at the tip. Comment on your results.

**OR**

**Que.2.** A long 20 cm diameter cylindrical shaft made of stainless steel 304 comes out of an oven at a uniform temperature of 600°C. The shaft is then allowed to cool in an environment chamber at 200°C with an average heat transfer coefficient of 80 W/$m^2$.°C. Determine the temperature at the center of the shaft 45 min after the start of the cooling process. Also, determine the heat transfer per unit length of the shaft during this time period. (k = 14.9 W/m-K, Cp = 477 J/kgK, ρ = 7900 kg/$m^3$). **(12)**

Que.3. (a) Define thermal diffusivity and discuss for liquid, metal and gas (5)

(b) Explain different mode of heat transfer (6)

## Section -II

Que.4. (a) Give the classification of Heat Exchanger (4)

(b) A simple heat exchanger is used for heating 1110 kg of oil per hour with specific heat 2.1 kJ/kg k from $27^0$C to $49^0$ C oil flow through inner pipe made of copper (OD= 2.86 cm, ID = 2.54 cm, k= 350 W/m K, oil side heat transfer coefficient 635 W/$m^2$ K heating source is water at $93^0$C flowing at the rate of 390 kg per hour with water side heat transfer coefficient as 1270 W/$m^2$ K. if fouling factors on the oil and water sides are 0.0001 and 0.0004 $m^2$-K/W, determine the length of heat exchanger under parallel and counter flow conditions. (8)

**OR**

Que.4. (a) A shell and tube steam condenser is to be constructed of 2.5 cm OD, 2.2 cm ID single pass horizontal tubes with steam condensing on the outside of the tube at $T_{sat}$= 54°C. Cooling water experiences a 18°C rise at it flows through the tubes at 0.7 kg/s and inlet temperature of 18°C. Shell side heat transfer coefficient can be assumed to be constant at 8 kW/$m^2$-K. Calculate the tube length and the condensation rate per tube. (8)

Properties at 27°C:

$$c_p = 4180 J/kg, \Pr = 5.9, k = 0.611 W/m-K, \mu = 860\times10^{-6} Pa-s$$

(b) Why is a counter flow heat exchanger more effective than a parallel flow heat exchanger? (4)

Que.5. A thin, flat plate that is 0.2 m by 0.2 m on a side is oriented parallel to an atmospheric airstream having a velocity of 40 m/s. The air is at a temperature of 20°C while the plate is maintained at 120°C. The air flows over the top and bottom surfaces of the plate, and measurement of drag force reveals a value of 0.075 N. What is the rate of heat transfer from both sides of the plate to the air? Properties of air ρ = 1.125 kg/m3 and μ= 18.4 × 10-6Pa.s, Pr = 0.71, k = 0.02635 W/m.K. (11)

**OR**

Que.5. Hot water at 90°C enters a 15 m section of a cast iron pipe (k = 52 W/m-K) whose inner and outer diameters are 4 and 4.6 cm respectively, at an average velocity of 0.8 m/s. The outer surface of the pipe whose emissivity is 0.7 is exposed to cold air in the basement at 10°C providing a convection coefficient of 15 W/$m^2$-K. Taking the walls of the basement to also be at 10°C, determine the heat loss from the water, the temperature at which water leaves the basement (11)

Que.6. (a) Explain briefly Stefan Boltzmann law (6)

(b) Define following dimensional number (6)

(i) Reynolds Number

(ii) Nusselt Number

(iii) Grashof Number

End of Paper

Best of Luck