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**Sixth Semester B.E. Degree Examination, June/July 2018**  
**Heat and Mass Transfer**

Time: 3 hrs.

Max. Marks:100

**Note: 1. Answer FIVE full questions, selecting at least TWO full questions from each part.**  
**2. Use of HMT data book is permitted.**

**PART – A**

- 1 a. State and explain the governing laws of conduction, convection and radiation heat transfer modes. (09 Marks)
- b. Write a note on thermal contact resistance. (03 Marks)
- c. A hollow spherical form is used to determine the thermal conductivity of material. The inner diameter is 20cm and the outer diameter is 50cm. A 30W heater is placed inside and under steady state conditions, the temperature at 15 and 20cm radii were found to be 80 and 60°C. Determine the thermal conductivity of the material. Also find the outside temperature. If the surrounding is at 30°C, determine convection heat transfer coefficient over the surface. (08 Marks)

- 2 a. Show that for a hollow cylinder with variable thermal conductivity and one dimensional steady state heat conduction, the temperature variation is given by

$$T = -\frac{1}{\alpha} + \sqrt{\left(\frac{1}{\alpha} + T_1\right)^2 - \frac{Q \log_e \frac{r}{r_1}}{\pi K_o L \alpha}}$$

where  $\alpha = \text{constant}$

$K_o = \text{thermal conductivity at zero degree temperature.}$  (10 Marks)

- b. A rod ( $K = 200 \text{ W/mK}$ ) 5mm in diameter and 5cm long has its one end maintained at 100°C. The surface of the rod is exposed to ambient air at 25°C with convection heat transfer coefficient of 100W/m<sup>2</sup>K. Assuming other end is insulated, determine:
- The temperature of the rod at 20mm distance from the end at 100°C.
  - Heat dissipation rate from the surface of the rod.
  - Effectiveness.
  - Efficiency of fin. (10 Marks)

- 3 a. Derive the expressions of temperature variation, instantaneous heat transfer and total heat transferred for one dimensional transient heat conduction. (10 Marks)
- b. A thermo couple is used to measure the temperature in a gas stream. The junction is approximated as a sphere with thermal conductivity of 25W/mK. The properties of the junction are  $\rho = 9000 \text{ kg/m}^3$ ,  $C = 0.35 \text{ kJ/kg K}$ ,  $h = 250 \text{ W/m}^2\text{K}$ . Calculate the diameter of the junction if thermocouple measures 95% of the applied temperature difference in 3 sec. (04 Marks)

- c. Water pipes are to be buried underground in a wet soil ( $\alpha = 2.78 \times 10^{-5} \text{ m}^2/\text{h}$ ) which is initially at 4.5°C. The soil surface temperature suddenly drops to -5°C and remains at this value for 10 hrs. Calculate the minimum depth at which the pipes are laid if the surrounding soil temperature is to be maintained above 0°C. The soil may be considered as semi-infinite solid. Treat the present conditions as the condition of an semi infinite solid. (06 Marks)

- 4 a. Derive the correlation for natural convection heat transfer in terms of Grashoff, Prandtl and Nusselt number using dimensional analysis. (10 Marks)
- b. Air at 20°C and atmospheric pressure is flowing over a flat plate at a velocity of 3m/s. If the plate is 30cm wide and at a temperature of 60°C, calculate at  $x = 0.3\text{m}$ .
- Thickness velocity and thermal boundary layers.
  - Local and average friction coefficients.
  - Local and average heat transfer coefficients.
  - Total drag force on the plate. (10 Marks)

**PART - B**

- 5 a. Define and mention the significance of following dimensionless numbers:
- Reynolds Number
  - Prandtl Number
  - Nusselt Number
  - Stanton Number
  - Peclet Number. (10 Marks)
- b. Consider air at atmospheric pressure and 100°C enters a 2m long tube of 4cm diameter with a velocity of 9m/s. A 1kW electric heater is wound on the outer surface of the tube, find:
- Exit temperature of air
  - Mass flow rate of air
  - Wall temperature. Assume that the rate of heat absorption by air per unit area is uniform throughout the length of the tube. (10 Marks)
- 6 a. Classify heat exchangers. (04 Marks)
- b. Define the following:
- Fouling and fouling factor.
  - Effectiveness of heat exchanger.
  - Capacity rate and capacity ratio. (06 Marks)
- c. Calculate the exit temperature of the hot fluid and inlet temperature of the cold fluid for a counter flow heat exchanger having the following specifications.
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|---------------------------------------|--------------------------|
| Mass flow rate of hot and cold fluids | = 3 and 0.75 kg/s        |
| $C_p$ for hot and cold fluids         | = 1.05 and 4.2 kJ/kg K   |
| Inlet temperature of hot fluid        | = 500°C                  |
| Exit temperature of cold fluid        | = 85°C                   |
| Overall heat transfer coefficient     | = 450 W/m <sup>2</sup> K |
| Total surface area                    | = 1m <sup>2</sup>        |
- (10 Marks)
- 7 a. List out the assumptions made in Nusselt theory of Laminar film condensation on vertical plate. (05 Marks)
- b. With a neat sketch, explain the regimes of pool boiling. (08 Marks)
- c. A vertical square plate 30cm × 30cm is exposed to steam at atmospheric pressure. The plate temperature is 98°C. Calculate the heat transfer and mass of steam condensed per hour. (07 Marks)
- 8 a. Briefly explain the concept of black body. (04 Marks)
- b. For black body show that the intensity of normal radiation is  $1/\pi$  times the emissive power. (10 Marks)
- c. Liquid air boiling at -153°C is stored in a spherical container of diameter 320mm. The container is surrounded by concentric spherical shell of diameter 360mm in a room at 27°C. The space between the two spheres is evacuated. The surface of the sphere are flashed with aluminium ( $\epsilon = 0.3$ ). Taking the latent heat of vapourization of liquid air as 210 kJ/kg, find the rate of evaporation of liquid air. (06 Marks)

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