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10ME63

# 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 $\alpha$ = constant

$K_o$ = thermal conductivity at zero degree temperature. **(10 Marks)**

b. A rod (K = 200 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$^2$K. Assuming other end is insulted, determine:

i) The temperature of the rod at 20mm distance from the end at 100°C.
ii) Heat dissipation rate from the surface of the rod.
iii) Effectiveness.
iv) 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 kg/m$^3$, C = 0.35 kJ/kg K, h = 250 W/m$^2$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 ($\alpha = 2.78 \times 10^{-5}$ m$^2$/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, Prandtle 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 = 0.3m.

i) Thickness velocity and thermal boundary layers.
ii) Local and average friction coefficients.
iii) Local and average heat transfer coefficients.
iv) Total drag force on the plate. **(10 Marks)**

## PART – B

5 a. Define and mention the significance of following dimensionless numbers:

i) Reynolds Number
ii) Prandtle Number
iii) Nusselt Number
iv) Stanton Number
v) 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: i) Exit temperature of air ii) Mass flow rate of air iii) 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:

i) Fouling and fouling factor.
ii) Effectiveness of heat exchanger.
iii) 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$^2$K |
| Total surface area | = 1m$^2$ |

**(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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