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**10AU65**

## Sixth Semester B.E. Degree Examination, Dec.2019/Jan.2020
# Heat & Mass Transfer



Time: 3 hrs. Max. Marks:100

**Note:** ***Answer FIVE full questions, selecting at least TWO questions from each part.***

## PART – A

1 a. Derive the general three dimensional heat conduction equation in Cartesian co-ordinate system. **(10 Marks)**

b. State the modes of heat transfer with governing laws and equations. **(10 Marks)**

2 a. Explain critical insulation thickness. Show that $R_C = \dfrac{K}{h_o}$. **(06 Marks)**

b. Define, fin effectiveness and fin efficiency. **(04 Marks)**

c. A stainless steel fin (K = 20 W/mK) having a diameter of 20 mm and a length of 0.1 m is attached to a wall at 300°C. The ambient temperature is 50°C and the heat transfer co-efficient is 10 W/m$^2$K the FIN tip is insulated. Determine

(i) The rate of heat dissipation from the FIN.
(ii) Temperature at the FIN tip.
(iii) Heat transfer from the wall area covered by the FIN, if FIN was not used. **(10 Marks)**

3 a. Show that the temperature distribution under lumped analysis is given by $\dfrac{T - T_\infty}{T_o - T_\infty} = e^{-B_i F_o}$. **(10 Marks)**

b. What is lumped system analysis? When is it applicable? What is its physical significance of BIOT number? **(06 Marks)**

c. The average heat transfer co-efficient for flow of 100°C air over a flat plate is measured by observing the temperature time history of 30 mm thick. Copper slab exposed to 100°C air, in one test run, the initial temperature of plate was 210°C and in five minutes the temperature is decreased by 40°C. Calculate, heat transfer co-efficient for this case. Take, $\rho = 9000$ kg/m$^3$, C = 0.38 KJ/kgK, K = 370 W/mK. **(04 Marks)**

4 a. What do you mean by hydrodynamic and thermal boundary layers? **(04 Marks)**

b. Explain the physical significance of, (i) Grushoff number (ii) Prandtl number (iii) Nusselt number (iv) Reynold's number (v) Stanton number. **(10 Marks)**

c. A nuclear reactor with its core constructed of parallel vertical plate 2.2 m high and 1.4 m wide has been designed on free convection heating of liquid Bismuth. The maximum temperature of the plate surface is limited to 960°C, while the lowest allowable temperature of Bismuth is 340°C. Calculate the maximum possible heat dissipation from both sides of each plate. Use,

$\text{Nu} = 0.13(G_r P_r)^{0.33}$, $\rho = 10^4$ kg/m$^3$, $\mu = 3.66\times10^{-4}$ kg/ms,

$C_P = 150.7$ J/kg°C, $K = 13.02$ W/m°C, $\beta = 1.08\times10^{-3}$ K$^{-1}$. **(06 Marks)**

## PART – B

5 a. Air at 20°C and atmospheric pressure is flowing over a flat plate at a velocity of 3 m/s. If the plate is 30 cm wide and at a temperature of 60°C, calculate the following quantities at $x = 0.3$ m. Take, $\rho = 1.18$ kg/m$^3$, $\nu = 17 \times 10^{-6}$ m$^2$/s, $K = 0.0272$ W/m°C, $C_P = 1.007$ KJ/kg, $P_r = 0.705$.
Calculate
(i) Thickness of velocity and thermal boundary layer.
(ii) Local and average friction co-efficient.
(iii) Local and average heat transfer co-efficient.
(iv) Total drag force on the plate. **(10 Marks)**

b. Water flows with a velocity of 0.6 m/s through a tube of inside diameter 60 mm and length 3.5 m. Find the heat transfer rate by forced convection if mean water temperature is 50°C and tube wall surface temperature is 70°C. Using empirical correlation $Nu = 0.023, (\mathrm{Re})^{0.8} (\mathrm{Pr})^{0.4}$. **(10 Marks)**

6 a. Derive an expression for LMTD of a counter flow heat exchanger. **(10 Marks)**

b. A cross flow heat exchanger (both fluids unmixed) and having a heat transfer area of 8.4 m$^2$ is to heat air ($C_P$ = 1.005 KJ/kgK) with water ($C_P = 4.18$ KJ/kgK). Air enters exchanger at 18°C with a mass flow rate of 2 kg/s. While water enters at 90°C with a mass flow rate of 0.25 kg/s. The overall h = 250 W/m$^2$K. Calculate the Exit temperature of the two fluids and the heat transfer rate. **(10 Marks)**

7 a. With the help of boiling curve explain the various regimes of boiling. **(10 Marks)**

b. Air free saturated steam at 85°C and pressure of 57.8 KPa. Condenses on the outer surface of 225 horizontal tubes 1.27 cm OD arranged in a $15 \times 15$ array. Tube surface is maintained at a uniform temperature of 75°C. Calculate total condensation rate per motor length of the tube bundle. **(10 Marks)**

8 a. Explain (i) Stefan Boltzman law (ii) Kirchoff's law (iii) Plank's law. **(10 Marks)**

b. Explain the concept of a black body by a neat sketch. **(10 Marks)**

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