B

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2019

Mechanical Engineering
(Thermal Engineering)

03ME 6011 Advanced Heat Transfer

Max. Marks : 60 Duration: 3 Hrs

Part A

*(Answer **all** questions)*

1. Derive the governing equation for a longitudinal fin of rectangular profile radiating to free space.
2. What is the physical significance of Nusselt number? How is Nusselt number different from Biot number?
3. Employ scale analysis to show that the length scale corresponding to the location of maximum velocity in free convection over an isothermal flat plate ($Pr \ll 1$), $\delta_v \sim HGr^{-1/4}$.
4. What are the radiation surface and space resistances? How are they expressed?

(4×5=20)

Part B

5.a. The heat transfer coefficient for air flowing over a sphere is to be determined by observing the temperature–time history of a sphere fabricated from pure copper. The sphere, which is 12.7 mm in diameter, is at 66^{o}C before it is inserted into an airstream having a temperature of 27^{o}C. A thermocouple on the outer surface of the sphere indicates 55^{o}C, 69 s after the sphere is inserted into the airstream. Assume and then justify that the sphere behaves as a lumped system and calculate the heat transfer coefficient.

OR

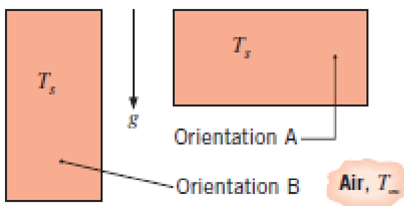
b. Derive the expression for the steady state temperature distribution and heat transfer for a longitudinal fin of rectangular profile. Assume convection from the tip of the fin.

6.a. Employ scale analysis to arrive at expressions for skin friction coefficient and Nusseltnumber (in an order-of-magnitude sense) for the flow of a highPrandtl number fluid (Pr>>1) over an infinitely thin isothermal flat plate.

OR

b. The wind blows at 0.6 m/s parallel to the short side of a flat roof with rectangular area 5 m × 10 m. The roof temperature is 40◦C, and the temperature of the air free stream is 20◦C. Calculate the total force experienced by the roof. Estimate also the total heat transfer rate by laminar forced convection from the roof to the atmosphere. If suddenly, the wind blows parallel to the longer side, will the total force on the roof and the heat transfer increase or decrease? Why?

7.a. Consider a vertical plate of dimension 0.25 m × 0.50 m that is at T_s = 100°C in a quiescent environment at T_∞= 20°C. In the interest of minimizing heat transfer from the plate,which orientation, (A) or (B), is preferred? What is the convection heattransfer from the front surface of the plate when it is in the preferred orientation?



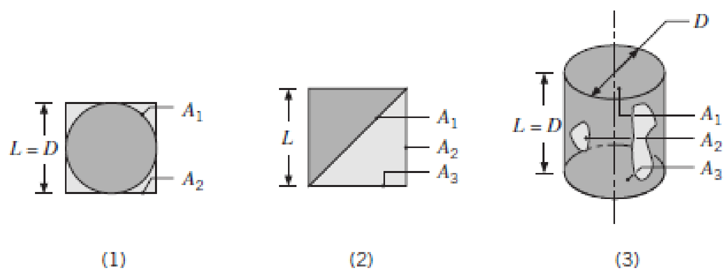
OR

b. Employ scale analysis of the thermal boundary layer region ($\delta_T \times L$) near an isothermal vertical wall and show that for high Prandtl number fluids, the $\delta_T$region is ruled by a friction-buoyancy balance and for low Prandtl number fluids the same region is ruled by inertia-buoyancy balance.

8.a. A furnace having a spherical cavity of 0.5-m diameter contains a gas mixture at 1 atm and 1400 K. The mixture consists of CO_2 with a partial pressure of 0.25 atm and nitrogen with a partial pressure of 0.75 atm. If the cavity wall is black, what is the cooling rate needed to maintain its temperature at 500 K?

OR

b. Determine the view factors F_{12} and F_{21} for the following geometries:



1. Sphere of diameter D inside a cubical box of length L
2. One side of a diagonal partition within a long square duct.
3. End and side of a circular tube of equal length and diameter.

(4×10=40)