Heat Transfer (CH21004)

Assignment - 1

Due date: 5th February, 2020

Each problem carries equal marks Full Marks - 20

1. Consider a flat plate subject to parallel flow (top and bottom) characterized by U_∞= 5 m/s, T_∞= 20°C.
   (a) Determine the convection heat transfer coefficient at L= *0.5* m and 2 m respectively from the leading edge.
   (b) Determine the thickness of the thermal and hydrodynamic boundary layer at L= *0.5* m.

2. A long, cylindrical, electrical heating element of diameter D = 10 mm is installed in a duct for which air moves in cross flow over the heater at a temperature and velocity of 27°C and 10 m/s, respectively. Estimate the steady-state surface temperature when, electrical energy per unit length of the heater is being dissipated at a rate of 1000 W/m.

3. A pre-heater involves the use of condensing steam at100°C on the inside of a bank of tubes to heat air that enters at 1 atm and 25°C. The air moves at 5 m/s in cross flow over the tubes. Each tube is 1 m long and has an outside diameter of 10 mm. The bank consists of 196 tubes in a square, aligned array for which $S_T = S_L$ = 15 mm. What is the total rate of heat transfer to the air?

4. Copper spheres of 20 mm diameter are quenched by being dropped into a tank of water that is maintained at 280 K. The spheres may be assumed to reach the terminal velocity (2 m/s) on impact and to drop freely through the water. What is the approximate height of the water tank needed to cool the spheres from an initial temperature of 360 K to 320 K? Assume no spatial variation inside the sphere.

5. A copper wire of diameter 2 mm carries a current "density" (really, a current *per area*) of 1000 A/cm^2. It is insulated with a material that has a thermal conductivity of 10^{-3} W/cm K. The electrical resistance of copper is 2×10^{-6} Ω cm. Determine the required air velocity if you want to maintain the outer surface of the insulation at 25°C and the ambient air temperature is 20°C.