New Problems Chapter 15

15.1-3. ***Dimensional analysis to get Stanton Number.*** Repeat the dimensional analysis for forced convection heat transfer to a vertical plate as given in Section 15.1. However, do as follows:

(a) Carry out all the detailed steps solving for all the exponents in the π's.
(b) Repeat, but in this case select the four variables *D, r, v, and Cp* to be common to all the dimensionless groups.

15.2-3 ***Thermal and Hydrodynamic Boundary Layer Thicknesses.*** Water at 298 K and 101.3 kPa with a free stream velocity of 5 m/s is flowing parallel to a smooth, flat plate held at a surface temperature of 435 K. At the critical Reynolds number of $N_{RE} = 1 \times 10^5$ calculate the critical length $x = L$ of the plate, the thickness d of the hydrodynamic boundary layer (use equation 11.1-6), and the thickness δ_T of the thermal boundary layer

15.3-6 ***Simplified Heat Transfer Coefficient for Flow inside a Pipe.*** Steam at 260°C and 1 atm flows through an 8-in. schedule-80 steel pipe at a rate of 10,000 lb/hr. Estimate the value of $h[=]\dfrac{BTU}{hr \cdot ft^2 \cdot °F}$ which applies at the inside pipe surface. Assuming the steam has the following constant properties

$\rho = 0.026\dfrac{lb}{ft^3}$, $\text{Cp} = 0.47\dfrac{BTU}{lb \cdot R}$, $\mu = 1.883\times10^{-5}\dfrac{kg}{m \cdot s}$, and $\text{k} = 0.03946\dfrac{W}{m \cdot K}$., and the viscosity at the wall is close to that of bulk, so the correction can be ignored.

15.4-5 ***Simplified Heat Transfer Coefficient for Flow Outside a flat plate.*** Steam at 280°C and 1 atm flows (20 m/s) parallel to a flat plat 100 cm long. Estimate the value of $h[=]\dfrac{W}{m^2 \cdot K}$ which applies at the outside of the plat. Assuming the steam has the following constant properties at its film temperature.

$\rho = 0.41\dfrac{kg}{m^3}$, $\text{Cp} = 1.97\dfrac{kJ}{kg \cdot K}$, $\mu = 1.9\times10^{-5}\dfrac{kg}{m \cdot s}$, and $\text{k} = 0.04\dfrac{W}{m \cdot K}$.

15.5-9 ***Natural Convection Outside a Cylinder.*** Calculate the heat transfer coefficient for a cylinder 15 cm in diameter and 50.6°C, which is suspended horizontally in still air at 25°C.

15.6-6 ***Condensation in a Horizontal Pipe.*** Benzene is flowing inside a horizontal, 1 m long, 1¼-in schedule 40 steel pipe at 37.8°C and a velocity of 1.5 m/s. Steam at 110°C is condensing on the outside of the pipe wall to heat the benzene inside the pipe.

a) What is the outside heat transfer coefficient (h_O) for the steam condensing on the pipe with a wall temperature of 90°C?

b) If the inside coefficient is $h_i = 500\dfrac{W}{m^2 \cdot K}$, calculate the overall inside coefficient (U_i). Ignore the thermal conductivity of the pipe because of its low thermal resistance.

15.7-3 ***Natural Convection Outside a Cylinder.*** Calculate the heat transfer coefficient for a cylinder 15 cm in diameter and 50.6°C, which is suspended horizontally in still air at 25°C.