Question 1 (25 Marks)

Water is to be heated from 15°C to 65°C as it flows through a 3-cm-internaldiameter 5-m-long tube. The tube is equipped with an electric resistance heater that provides uniform heating throughout the surface of the tube. The outer surface of the heater is well insulated, so that in steady operation all the heat generated in the heater is transferred to the water in the tube. If the system is to provide hot water at a rate of 10 L/min, determine the power rating of the resistance heater. Also, estimate the inner surface temperature of the pipe at the exit.
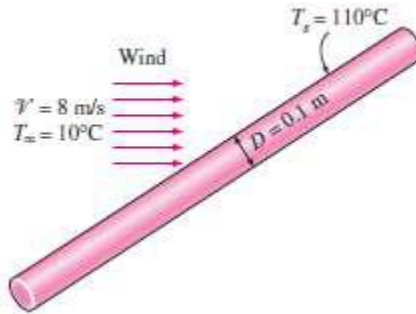
Question 2 (25 Marks)

Air at 20°C flows with a velocity of 8 m/s over a 1.5 m by 6 m flat plate whose temperature is 140°C. Determine the rate of heat transfer from the plate if the air flows parallel to the (*a*) 6-m-long side and (*b*) the 1.5-m side.

$P_{atm} = 83.4$ kPa

$T_{\infty} = 20°C$
$V = 8$ m/s

$T_s = 140°C$

Air

Q

6 m

1.5 m
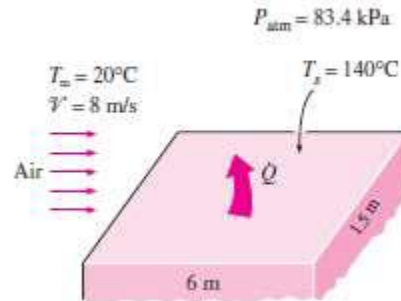
Question 3 (25 Marks)

A long 10-cm-diameter steam pipe whose external surface temperature is 110°C passes through some open area that is not protected against the winds. Determine the rate of heat loss from the pipe per unit of its length when the air is at 1 atm pressure and 10°C and the wind is blowing across the pipe at a velocity of 8 m/s.

Question 4 (25 Marks)

Water enters a 2.5-cm-internal-diameter thin copper tube of a heat exchanger at 15°C at a rate of 0.3 kg/s, and is heated by steam condensing outside at 120°C. If the average heat transfer coefficient is 800 W/m2 C, determine the length of the tube required in order to heat the water to 115°C.

Steam
$T_s = 120°C$

Water
15°C
0.3 kg/s

$D = 2.5$ cm

115°C