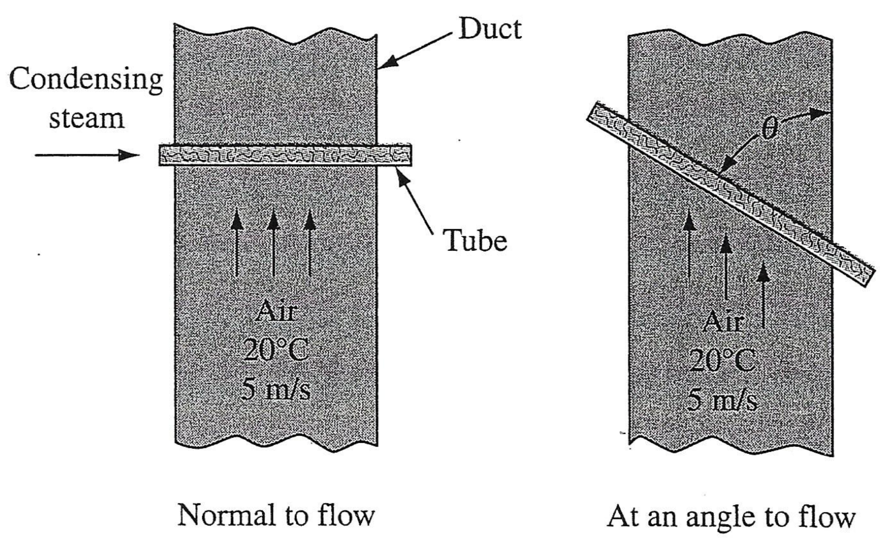
ASSIGNMENT #7

Convective Heat Transfer with Flow over Surfaces

7–1 Steam at 1 atm and 100°C is flowing across a 5-cm-OD tube at a velocity of 6 m/s. Estimate the Nusselt number, the heat transfer coefficient, and the rate of heat transfer per meter length of pipe if the pipe is at 200°C.

7–2 An engineer is designing a heating system that will consist of multiple tubes placed in a duct carrying the air supply for a building. She decides to perform preliminary tests with a single copper tube of 2-cm OD carrying condensing steam at 100°C. The air velocity in the duct is 5 m/s, and its temperature is 20°C. The tube can be placed normal to the flow, but it may be advantageous to place the tube at an angle to the air flow and thus increase the heat transfer surface area. If the duct width is 1 m, predict the outcome of the planned tests and estimate how the angle θ will affect the rate of heat transfer. Are there limits?



Normal to flow

At an angle to flow

7–3 A platinum hot-wire anemometer operated in the constant-temperature mode has been used to measure the velocity of a helium stream. The wire diameter is 20 μm, its length is 5 mm, and it is operated at 90°C. The electronic circuit used to maintain the wire temperature has a maximum power output of 5 W and is unable to accurately control the wire temperature if the voltage applied to the wire is less than 0.5 V. Compare the operation of the wire in the helium stream at 20°C and 10 m/s with its operation in air and water at the same temperature and velocity. The electrical resistance of the platinum at 90°C is 21.6 $\mu\Omega$ cm.

7–4 A copper sphere 2.5 cm in diameter is suspended by a fine wire in the center of an experimental hollow, cylindrical furnace whose inside wall is maintained uniformly at 430°C. Dry air at a temperature of 90°C and a pressure of 1.2 atm is blown steadily through the furnace at a velocity of 14 m/s. The interior surface of the furnace wall is black. The copper is slightly oxidized, and its emissivity is 0.4. Assuming that the air is completely transparent to radiation, calculate for the steady state: (a) the convection heat transfer coefficient between the copper sphere and the air and (b) the temperature of the sphere.

7–5 An electronic circuit contains a power resistor that dissipates 1.5 W. The designer wants to modify the circuitry in such a way that it will be necessary for the resistor to dissipate 2.5 W. The resistor is in the shape of a disk 1 cm in diameter and 0.6-mm thick. Its surface is aligned with a cooling air flow at 30°C and 10 m/s velocity. The resistor lifetime becomes unacceptable if its surface temperature exceeds 90°C. Is it necessary to replace the resistor for the new circuit?