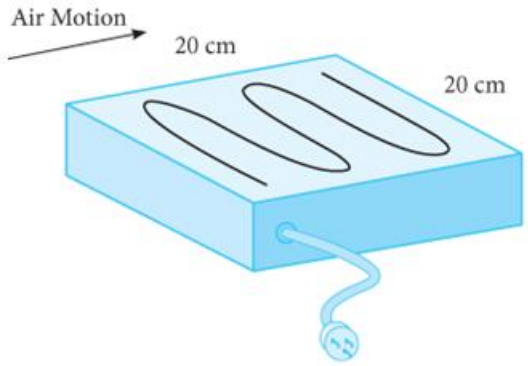
ME 313 Heat Transfer

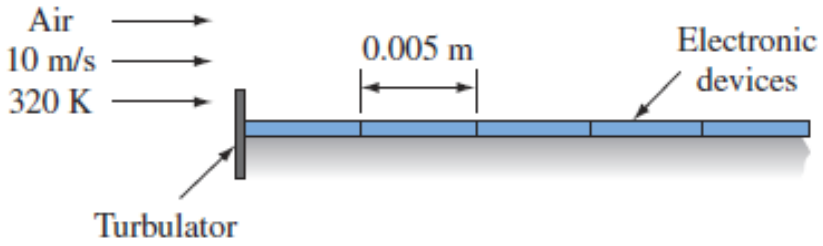
CHAPTER 7
Examples

Fall 2015

1) An electrical hot-plate of 20 cm × 20 cm uses 200 W of power when operating at steady state conditions. The surface of the plate is subjected to a stream of 27 ^{0}C air moving at 10 m/s parallel to the plate, as shown in Figure 4-30. Estimate the minimum and maximum plate temperatures at equilibrium and steady state. Plot the surface temperature as a function of x.



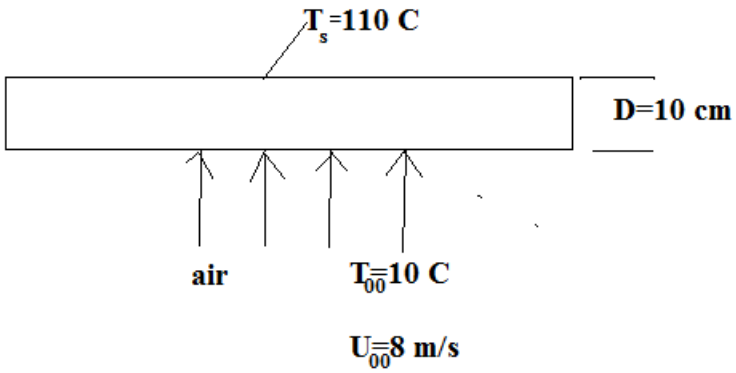
2) Air at 320 K with a free stream velocity of 10 m/s is used to cool small electronic devices mounted on a printed circuit board as shown in the sketch below. Each device is 5 mm by 5 mm square in plane-form and dissipates 60 milliwatts. A turbulator is located at the leading edge to trip the boundary layer so that it will become turbulent. Assuming that the lower surface of the electronic devices are insulated, estimate the surface temperature at the center of the fifth device on the circuit board.



3) For a study on global warming, an electronic instrument has to be designed to map and the CO_2 absorption characteristics of the Pacific Ocean. The instrument package resembles a flat plate with a total (upper and lower) surface area of 2 m^2. For safe operation, its surface temperature must not exceed the ocean temperature by 2°C. To monitor the temperature of the instrument package, which is towed by a ship moving at 20 m/s, the tension in the towing cable is measured. If the tension is 400 N, calculate the maximum permissible heat generation rate from the instrument package

4) Engine oil at $25\,^0C$ is forced to flow over a 30 cm $\times$ 20 cm plate at a velocity of 1.5 m/s .The flow is parallel to the 30 cm side, which is heated to a uniform temperature of $55\,^0C$ .Calculate the rate of heat transfer from the plate to the oil.

5) A long 10 diameter steam pipe is exposed to atmospheric air at $4\,^0C$ .The outer surface of the pipe is at $110\,^0C$ and air is flowing across the pipe at a velocity of 8 m/s.



Determine the rate of heat loss from the pipe per unit of its length.

6) A 10-kW heater is constructed of a glass plate with electrically conducting film which produces a constant heat flux. The plate is 60 cm by 60 cm and placed in an air stream at $27\,^0C$, 1 atm with $U_\infty = 5m/s$ .Calculate the average temperature difference along plate and the temperature difference at the trailing edge.

Example 7

Air at 1 atm and 300 K flows across a 20 cm square plate at a free stream velocity of 20 m/s. The last half of the plate is heated to a constant temperature of 350 K. Calculate the heat lost by the plate.

Example 8

Engine oil at 293 K is forced over a 20 cm square plate at velocity of 1.2 m/s .The plate is heated to a uniform temperature of 333 K. Calculate the heat lost from the plate.

Example 9

Air at 293 K and 1 atm flows over a flat plate at 35 m/s. The plate is 75 cm long and is maintained at 333 K. Assuming width of the plate is 1 m, calculate the heat transfer from the plate.