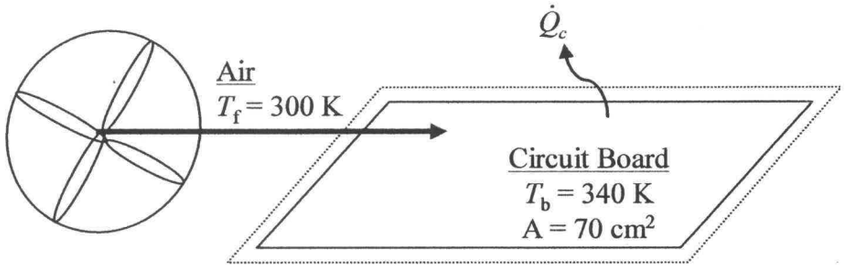
PROBLEM 2.43

KNOWN: A fan forces air to flow over a circuit board to avoid overheating.

FIND: Largest and smallest heat transfer rates associated with this forced convection.

SCHEMATIC AND GIVEN DATA:



ENGINEERING MODEL:
1. The circuit board is the system.
2. The system is at steady state.

ANALYSIS:
Newton's Law of Cooling is $\dot{Q}_c = hA(T_b - T_f)$, where $\dot{Q}_c$ is the rate of cooling heat transfer, h is the convection heat transfer coefficient, A is area of the surface, T_b is temperature of the surface, and T_f is temperature of the flowing fluid (air).

From Table 2.1 for forced convection using gases, the largest and smallest values for the convection heat transfer coefficient are
(Largest) h = 250 W/(m2·K)
(Smallest) h = 25 W/(m^2·K)

Substituting into Newton's Law of Cooling yields

$$\dot{Q}_c = \left(250\frac{\text{W}}{\text{m}^2\cdot\text{K}}\right)(70\,\text{cm}^2)\left|\frac{\text{m}^2}{(100\,\text{cm})^2}\right|(340\,\text{K} - 300\,\text{K}) = \underline{\textbf{70 W (largest heat transfer rate)}}$$

and

$$\dot{Q}_c = \left(25\frac{\text{W}}{\text{m}^2\cdot\text{K}}\right)(70\,\text{cm}^2)\left|\frac{\text{m}^2}{(100\,\text{cm})^2}\right|(340\,\text{K} - 300\,\text{K}) = \underline{\textbf{7 W (smallest heat transfer rate)}}$$