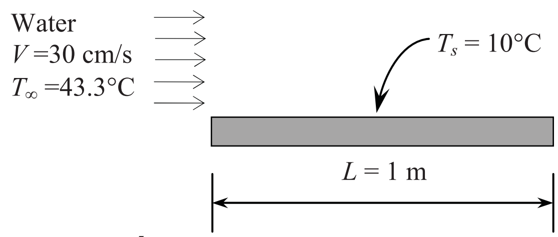
12-46 Water flows over a large plate. The rate of heat transfer per unit width of the plate is to be determined.

Assumptions **1** Steady operating conditions exist. **2** The critical Reynolds number is $Re_{cr} = 5\times10^5$. **3** Radiation effects are negligible.

Properties The properties of water at the film temperature of $(T_s + T_\infty)/2 = (10+43.3)/2 = 27°C$ are (Table A-15)

$$\rho = 996.6\ \text{kg/m}^3$$
$$k = 0.610\ \text{W/m.°C}$$
$$\mu = 0.854\times10^{-3}\ \text{kg//m}\cdot\text{s}$$
$$\text{Pr} = 5.85$$



Analysis (*a*) The Reynolds number is

$$\text{Re}_L = \frac{VL\rho}{\mu} = \frac{(0.3\ \text{m/s})(1.0\ \text{m})(996.6\ \text{kg/m}^3)}{0.854\times10^{-3}\ \text{m}^2\text{/s}} = 3.501\times10^5$$

which is smaller than the critical Reynolds number. Thus we have laminar flow for the entire plate. The Nusselt number and the heat transfer coefficient are

$$\text{Nu} = 0.664\,\text{Re}_L^{1/2}\,\text{Pr}^{1/3} = 0.664(3.501\times10^5)^{1/2}(5.85)^{1/3} = 707.9$$

$$h = \frac{k}{L}\text{Nu} = \frac{0.610\ \text{W/m.°C}}{1.0\ \text{m}}(707.9) = 431.8\ \text{W/m}^2\text{.°C}$$

Then the rate of heat transfer per unit width of the plate is determined to be

$$\dot{Q} = hA_s(T_s - T_\infty) = (431.8\ \text{W/m}^2\text{.°C})(1\ \text{m})(1\ \text{m})](43.3-10)°\text{C} = \mathbf{14{,}400\ W}$$