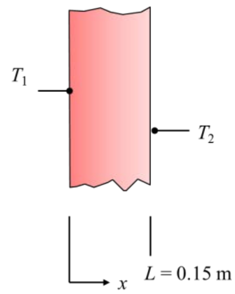
PROBLEM 1.1

KNOWN: Temperature distribution in wall of Example 1.1.

FIND: Heat fluxes and heat rates at $x = 0$ and $x = L$.

SCHEMATIC:



ASSUMPTIONS: (1) One-dimensional conduction through the wall, (2) constant thermal conductivity, (3) no internal thermal energy generation within the wall.

PROPERTIES: Thermal conductivity of wall (given): $k = 1.7$ W/m·K.

ANALYSIS: The heat flux in the wall is by conduction and is described by Fourier's law,

$$q''_x = -k\frac{dT}{dx} \qquad (1)$$

Since the temperature distribution is $T(x) = a + bx$, the temperature gradient is

$$\frac{dT}{dx} = b \qquad (2)$$

Hence, the heat flux is constant throughout the wall, and is

$$q''_x = -k\frac{dT}{dx} = -kb = -1.7\ \text{W/m}\cdot\text{K} \times \left(-1000\ \text{K/m}\right) = 1700\ \text{W/m}^2 \qquad <$$

Since the cross-sectional area through which heat is conducted is constant, the heat rate is constant and is

$$q_x = q''_x \times (W \times H) = 1700\ \text{W/m}^2 \times \left(1.2\ \text{m} \times 0.5\ \text{m}\right) = 1020\ \text{W} \qquad <$$

Because the heat rate into the wall is equal to the heat rate out of the wall, steady-state conditions exist. <

COMMENTS: (1) If the heat rates were not equal, the internal energy of the wall would be changing with time. (2) The temperatures of the wall surfaces are $T_1 = 1400$ K and $T_2 = 1250$ K.