

PROBLEM 1.1

KNOWN: Dimensions and material properties of a composite wall.

FIND: (a) Heat loss per unit area of the wall, (b) Temperature distribution across the wall.

SCHEMATIC: A composite wall consisting of three layers: brick, insulation, and brick.

ASSUMPTIONS: (1) Steady-state conditions, (2) One-dimensional conduction, (3) Negligible convection resistance on the inner and outer surfaces.

PROPERTIES: (1) Brick: $k = 0.7 \text{ W/m}\cdot\text{K}$, (2) Insulation: $k = 0.026 \text{ W/m}\cdot\text{K}$.

ANALYSIS: (a) The heat loss per unit area of the wall is given by

$$q = \frac{T_1 - T_2}{R_{\text{total}}} = \frac{T_1 - T_2}{\frac{L_1}{k_1} + \frac{L_2}{k_2} + \frac{L_3}{k_3}}$$

$$q = \frac{20^\circ\text{C} - 0^\circ\text{C}}{\frac{0.1 \text{ m}}{0.7 \text{ W/m}\cdot\text{K}} + \frac{0.05 \text{ m}}{0.026 \text{ W/m}\cdot\text{K}} + \frac{0.1 \text{ m}}{0.7 \text{ W/m}\cdot\text{K}}} = 1.14 \text{ W/m}^2$$

(b) The temperature distribution across the wall is shown in the schematic below.

The temperature distribution is linear in each layer, with the steepest slope in the insulation layer.

The temperature distribution is shown in the schematic below.

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