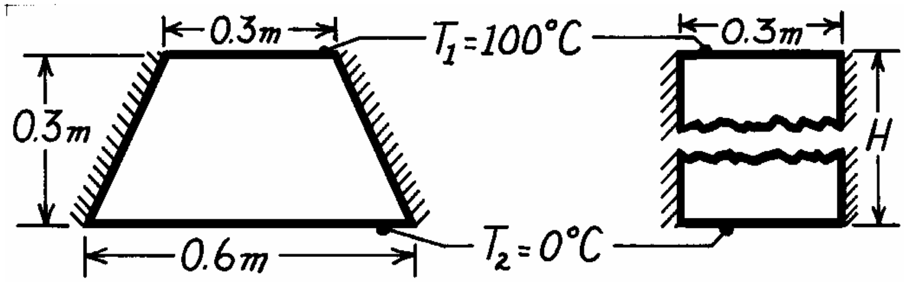
PROBLEM 4S.6

KNOWN: Shape and surface conditions of a support column.

FIND: (a) Heat transfer rate per unit length. (b) Height of a rectangular bar of equivalent thermal resistance.

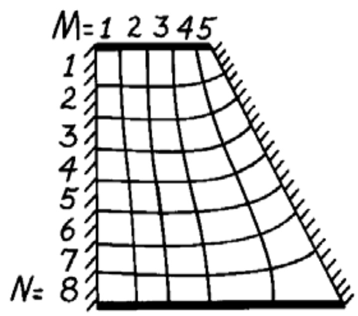
SCHEMATIC:



ASSUMPTIONS: (1)Steady-state conditions, (2) Negligible three-dimensional conduction effects, (3) Constant properties, (4) Adiabatic sides.

PROPERTIES: *Table A-1*, Steel, AISI 1010 (323K): k = 62.7 W/m·K.

ANALYSIS: (a) From the flux plot for the half section, M ≈ 5 and N ≈ 8. Hence for the full section



$$S = 2\frac{M\ell}{N} \approx 1.25\ell$$

$$q = Sk(T_1 - T_2)$$

$$q' \approx 1.25 \times 62.7\frac{W}{m\cdot K}(100-0)^\circ C$$

$$q' \approx 7.8 \text{ kW/m.}$$ <

(b) The rectangular bar provides for one-dimensional heat transfer. Hence,

$$q = k\,A\frac{(T_1 - T_2)}{H} = k(0.3\ell)\frac{(T_1 - T_2)}{H}$$

Hence,

$$H = \frac{0.3k(T_1 - T_2)}{q'} = \frac{0.3m(62.7 \text{ W/m}\cdot K)(100^\circ C)}{7800 \text{ W/m}} = 0.24m.$$ <

COMMENTS: The fact that H < 0.3m is consistent with the requirement that the thermal resistance of the trapezoidal column must be less than that of a rectangular bar of the same height and top width (because the width of the trapezoidal column increases with increasing distance, x, from the top). Hence, if the rectangular bar is to be of equivalent resistance, it must be of smaller height.