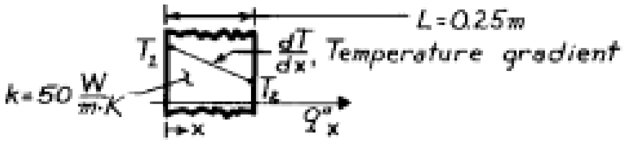
PROBLEM 2.8

KNOWN: One-dimensional system with prescribed thermal conductivity and thickness.

FIND: Unknowns for various temperature conditions and sketch distribution.

SCHEMATIC:



ASSUMPTIONS: (1) Steady-state conditions, (2) One-dimensional conduction, (3) No internal heat generation, (4) Constant properties.

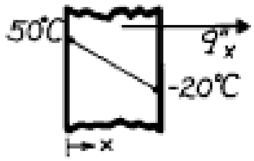
ANALYSIS: The rate equation and temperature gradient for this system are

$$q''_x = -k\frac{dT}{dx} \qquad \text{and} \qquad \frac{dT}{dx} = \frac{T_2 - T_1}{L}. \qquad (1,2)$$

Using Eqs. (1) and (2), the unknown quantities for each case can be determined.

(a) $$\frac{dT}{dx} = \frac{(-20-50)K}{0.25m} = -280 \text{ K/m}$$

$$q''_x = -50\frac{W}{m\cdot K}\times\left[-280\frac{K}{m}\right] = 14.0 \text{ kW/m}^2.$$



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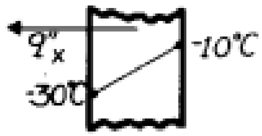
(b) $$\frac{dT}{dx} = \frac{(-10-(-30))K}{0.25m} = 80 \text{ K/m}$$

$$q''_x = -50\frac{W}{m\cdot K}\times\left[80\frac{K}{m}\right] = -4.0 \text{ kW/m}^2.$$



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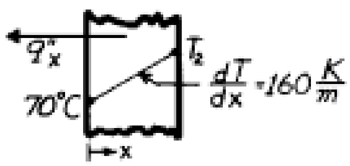
(c) $$q''_x = -50\frac{W}{m\cdot K}\times\left[160\frac{K}{m}\right] = -8.0 \text{ kW/m}^2$$

$$T_2 = L\cdot\frac{dT}{dx} + T_1 = 0.25m\times\left[160\frac{K}{m}\right] + 70^\circ C.$$

$$T_2 = 110^\circ C.$$



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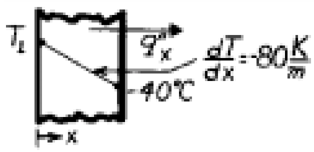
(d) $$q''_x = -50\frac{W}{m\cdot K}\times\left[-80\frac{K}{m}\right] = 4.0 \text{ kW/m}^2$$

$$T_1 = T_2 - L\cdot\frac{dT}{dx} = 40^\circ C - 0.25m\left[-80\frac{K}{m}\right].\in$$

$$T_1 = 60^\circ C.$$



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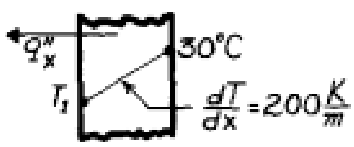
(e) $$q''_x = -50\frac{W}{m\cdot K}\times\left[200\frac{K}{m}\right] = -10.0 \text{ kW/m}^2$$

$$T_1 = T_2 - L\cdot\frac{dT}{dx} = 30^\circ C - 0.25m\left[200\frac{K}{m}\right] = -20^\circ C.$$



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