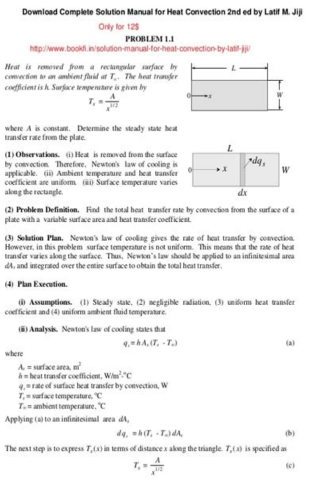

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PROBLEM 1.1

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Heat is removed from a rectangular surface by convection to an ambient fluid at T_∞. The heat transfer coefficient is h. Surface temperature is given by

$$T_s = \frac{A}{x^{1/2}}$$

where A is constant. Determine the steady state heat transfer rate from the plate.

(1) Observations. (i) Heat is removed from the surface by convection. Therefore, Newton's law of cooling is applicable. (ii) Ambient temperature and heat transfer coefficient are uniform. (iii) Surface temperature varies along the rectangle.

(2) Problem Definition. Find the total heat transfer rate by convection from the surface of a plate with a variable surface area and heat transfer coefficient.

(3) Solution Plan. Newton's law of cooling gives the rate of heat transfer by convection. However, in this problem surface temperature is not uniform. This means that the rate of heat transfer varies along the surface. Thus, Newton's law should be applied to an infinitesimal area dA_s and integrated over the entire surface to obtain the total heat transfer.

(4) Plan Execution.

(i) Assumptions. (1) Steady state, (2) negligible radiation, (3) uniform heat transfer coefficient and (4) uniform ambient fluid temperature.

(ii) Analysis. Newton's law of cooling states that

$$q_s = h A_s (T_s - T_\infty) \quad (a)$$

where

A_s = surface area, m^2
h = heat transfer coefficient, W/m^2-°C
q_s = rate of surface heat transfer by convection, W
T_s = surface temperature, °C
T_∞ = ambient temperature, °C

Applying (a) to an infinitesimal area dA_s

$$dq_s = h (T_s - T_\infty) dA_s \quad (b)$$

The next step is to express $T_s(x)$ in terms of distance x along the triangle. $T_s(x)$ is specified as

$$T_s = \frac{A}{x^{1/2}} \quad (c)$$

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