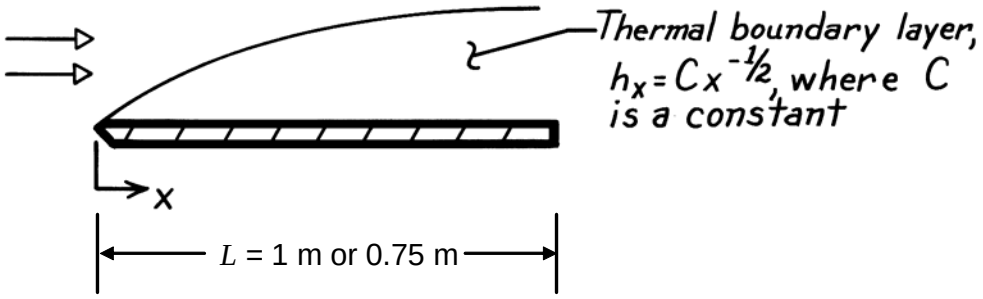
PROBLEM 6.6

KNOWN: Variation of local heat transfer coefficient with *x*. Length of plate.

FIND: Ratio of heat transfer coefficients for flow oriented in short and long directions.

SCHEMATIC:



ASSUMPTIONS: (1) Steady-state conditions, (2) Laminar flow, (3) Incompressible flow.

ANALYSIS: The local heat transfer coefficient varies with *x* according to

$$h_x = Cx^{-1/2}$$

The average heat transfer coefficient over the entire plate is given by Eq. 6.10:

$$\bar{h}_L = \frac{1}{L}\int_0^L h_x dx = \frac{1}{L}\int_0^L Cx^{-1/2} dx = 2CL^{-1/2}$$

Therefore the ratio of average heat transfer coefficients for the two different flow orientations is

$$\frac{\bar{h}_{L,1}}{\bar{h}_{L,2}} = \left(\frac{L_2}{L_1}\right)^{1/2}$$

The average heat transfer coefficient is larger when the flow is oriented in the short direction because local heat transfer coefficients are largest near the leading edge. Therefore the heat transfer rate will be larger when flow is oriented in the short direction. <

COMMENTS: Many engineering devices that are affected by, or utilize convection heat transfer in their operation incorporate short sections of surfaces in order to take advantage of the high local heat transfer coefficients that exist near the leading edges of such surfaces.