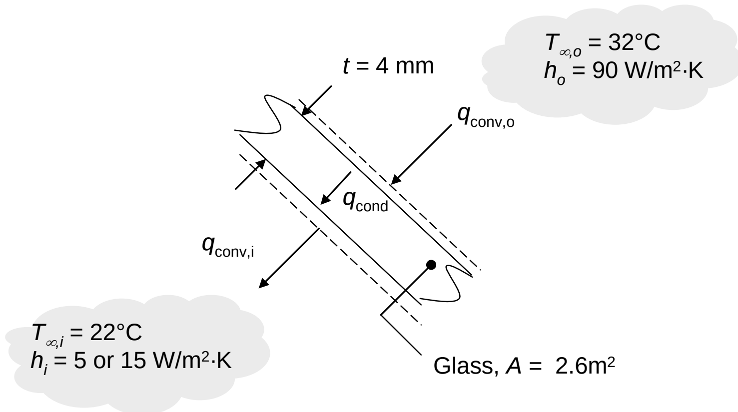
PROBLEM 3.20

KNOWN: Window surface area and thickness, inside and outside heat transfer coefficients, outside and passenger compartment temperatures.

FIND: Heat loss through the windows for high and low inside heat transfer coefficients.

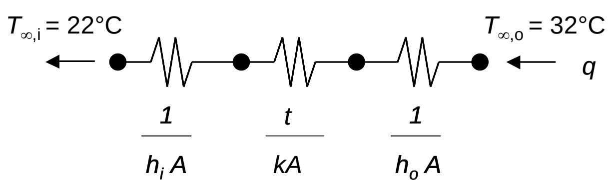
SCHEMATIC:



ASSUMPTIONS: (1) Steady-state, one-dimensional conduction. (2) Constant properties. (3) Negligible radiation.

PROPERTIES: Table A.3, glass (T = 300 K): k = 1.4 W/m·K.

ANALYSIS: The thermal circuit is



from which the heat transfer rate through the windows for $h_i = 15\ \text{W/m}^2\cdot\text{K}$ is

$$q = \frac{T_{\infty,o} - T_{\infty,i}}{\left(\frac{1}{h_i A} + \frac{t}{kA} + \frac{1}{h_o A}\right)}$$

$$= \frac{(32-22)\,^\circ\text{C}}{\left(\frac{1}{15\ \text{W/m}^2\cdot\text{K}\times 2.6\ \text{m}^2} + \frac{4\times10^{-3}\ \text{m}}{1.4\ \text{W/m}\cdot\text{K}\times 2.6\ \text{m}^2} + \frac{1}{90\ \text{W/m}^2\cdot\text{K}\times 2.6\text{m}^2}\right)}$$

$$= 333\ \text{W}$$ <

Repeating the calculation for $h_i = 5\ \text{W/m}^2\cdot\text{K}$ yields $q = 121$ W <

Continued…

PROBLEM 3.20 (Cont.)

COMMENTS: (1) Assuming an air conditioner COP of 3, controlling the airflow in the passenger cabin to reduce the interior convection heat transfer coefficient will reduce the power consumed by the air conditioner by ΔP = (333 W – 121 W)/3 = 71 W. (2) A smaller air conditioner can be utilized with the lower interior heat transfer coefficient. This will both (a) reduce the cost of the air conditioner and (b) reduce the amount of refrigerant in the air conditioning unit. Reduction in the amount of refrigerant used will also reduce the level of refrigerant that might leak from the system, potentially reducing greenhouse gas emissions. (3) The individual resistance values are $R_{conv,i}$ = 0.026 K/W, R_{cond} = 0.0011 K/W, and $R_{conv,o}$ = 0.0043 K/W for h_i = 15 W/m^2·K.