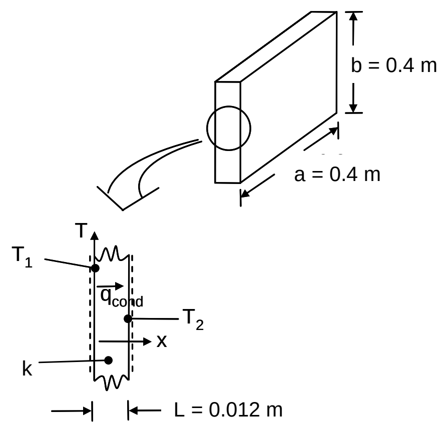
PROBLEM 2.19

KNOWN: Dimensions of and temperature difference across an aircraft window. Window materials and cost of energy.

FIND: Heat loss through one window and cost of heating for 130 windows on 8-hour trip.

SCHEMATIC:



ASSUMPTIONS: (1) Steady-state conditions, (2) One-dimensional conduction in the x-direction, (3) Constant properties.

PROPERTIES: Table A.3, soda lime glass (300 K): k_{gl} = 1.4 W/m·K.

ANALYSIS: From Eq. 2.1,

$$q_x = -kA\frac{dT}{dx} = k\,a\,b\frac{(T_1 - T_2)}{L}$$

For glass,

$$q_{x,g} = 1.4\ \frac{W}{m\cdot K} \times 0.4\ m \times 0.4\ m \times \left[\frac{90°C}{0.012m}\right] = 1680\ W \qquad <$$

The cost associated with heat loss through N windows at a rate of R = \$1/kW·h over a t = 8 h flight time is

$$C_g = Nq_{x,g}Rt = 130 \times 1680\ W \times 1\ \frac{\$}{kW\cdot h} \times 8\ h \times \frac{1kW}{1000W} = \$1750 \qquad <$$

Repeating the calculation for the polycarbonate yields

$$q_{x,p} = 252\ W,\ C_p = \$262 \qquad <$$

while for aerogel,

$$q_{x,a} = 16.8\ W,\ C_a = \$17.5 \qquad <$$

COMMENT: Polycarbonate provides significant savings relative to glass. It is also lighter (ρ_p = 1200 kg/m^3) relative to glass (ρ_g = 2500 kg/m^3). The aerogel offers the best thermal performance and is very light (ρ_a = 2 kg/m^3) but would be relatively expensive.