Heat Transfer Workshop 10 Window Conduction Introduction

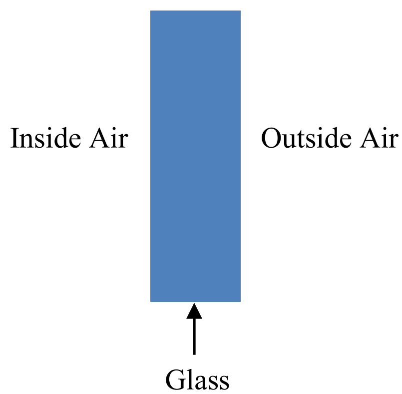
Name ___________________________

Windows are a major source of heat loss in buildings. Many older windows and storm doors use a single pane of glass, typically 1/8 inch thick. This is still the case in the older engineering buildings on our campus. In theory the thermal resistance of the window can be determined directly from measurements of the heat flux q'' and temperature difference across the glass ΔT. At steady-state conditions the conduction heat flux is

$$q'' = \frac{k}{L}\,(T_{inside} - T_{outside})$$

where k is the thermal conductivity of the glass and L is the thickness. The corresponding thermal resistance is

$$R'' = L/k$$



Note: In practice, it is very difficult to accurately measure the surface temperature of materials when heat transfer is occurring to or from the surface. Thermal contact resistance is relatively large, especially for the usual bead thermocouples. Flat, thin-film thermocouples are also available commercially and make better contact with the actual surface. Conversely, the heat flux is typically measured over a much larger area and at steady-state conditions, what goes in must come out. Consequently, contrary to popular opinion it is normally much easier to accurately measure heat flux on a surface than temperature.

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Heat Transfer Workshop 10 Window Conduction Results

Name ___________________________

To measure thermal resistance one would ideally make measurements on the inside and outside of the window at the same time, but since you only have one sensor you will do it sequentially. First, mount the heat flux sensor on the inside of a single pane window with the thermocouple on the side next to the glass. Measure the heat flux and temperature at steady-state. Then repeat for the outside of the window again with the thermocouple next to the surface. Use the second thermocouple to record the inside and outside air temperature. Record the steady-state values below and sketch the temperature distribution on the figure. **Draw and label the system with all measurements including the direction of the heat flux:**

$T_{glass\ inside}$ =

$T_{glass\ outside}$ =

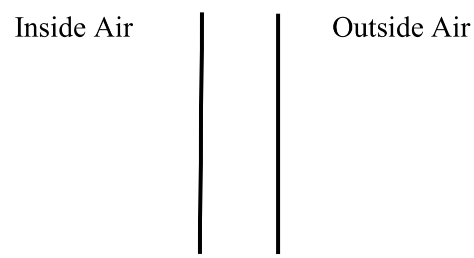
$T_{air\ inside}$ =

$T_{air\ outside}$ =

q''_{inside} =

$q''_{outside}$ =

$q''_{average}$ =



1. Why do the heat flux values have opposite sign between the inside and outside of the window?

2. Apply an energy balance around the window. What does it say about the relation between the heat flux values?

3. What reasons would cause the magnitude of heat flux measured values to not be equal?

4. Calculate the theoretical thermal resistance of the window. The thermal conductivity for glass is typically about k = 1.0 W/m-K and the thickness is about L = 3 mm. Using the measured heat flux value, find the theoretical temperature difference across the window.

   Theory: R'' = _________

   Theory: ΔT = _________

5. Find the thermal resistance using the measured surface temperatures with the measured heat flux.

   Measured: ΔT = _________

   Measured: R'' = _________

6. Why are measured values so different from the theory? Why is this method a failure? How could you fix it?