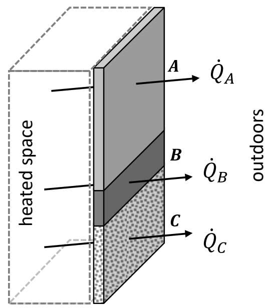
Problems

1. Estimate the 1-D U-value for each of the following simplified wall systems. For the indoor and outdoor surface heat transfer coefficients, use $h_{in} = 10\ W/m^2 \cdot K, h_{out} = 35\ W/m^2 \cdot K$.

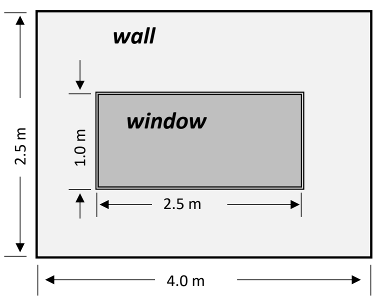
a) Plywood, 13 mm thick, k ≈ 0.12 W/m·K
b) ½ inch thick extruded polystyrene insulation, rated RSI = 0.44 $(W/m^2\text{-}K)^{-1}$
c) combine the two previous layers (plywood exterior, insulation interior)
d) 2 inch thick extruded polystyrene insulation, rated RSI = 1.76 $(W/m^2\text{-}K)^{-1}$
e) a single sheet (pane) of glass, 6 mm thick, k ≈ 1.0 W/m·K

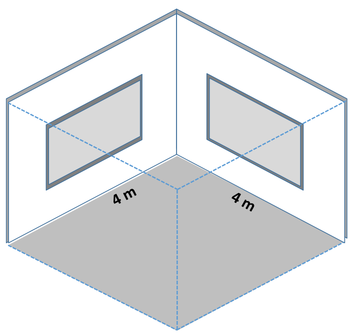
2. A building wall has total surface area of 100 m^2 and consists of three distinct sections with overall thermal resistance values as indicated below. For a period when ΔT = 10°C, estimate the steady-state heat loss rate (W) through each wall section and the total steady-state heat loss rate (W). Also, determine the average USI- and RSI-values for the whole wall (100 m^2).

Section	***Area,*** $\boldsymbol{m^2}$	***RSI,*** $\boldsymbol{(W/m^2 \cdot °C)^{-1}}$
A	60	4.58
B	10	1.06
C	30	2.82



3. In a large building, a corner room is 4 m × 4 m. IT is exposed to the outdoors through two exterior walls (USI = 0.38 $W/m^2\text{-}°C$), each 10 m^2 and containing a 2.5 m^2 window (USI = 2.06 $W/m^2\text{-}°C$). Air from outside flows into the room at 10 L/s and room-air flows out (to the outdoors) at the same rate.



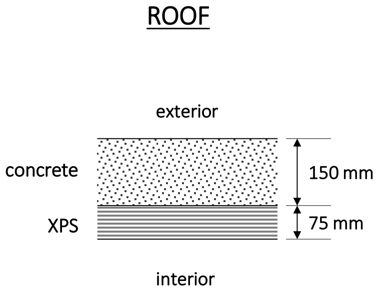


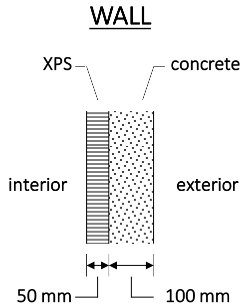
For a period when the outdoor air T = 0°C and the indoor air T = 20°C, determine the total rate of heating (W) needed to maintain the room's temperature. Also, assess the percent contribution of each "heat loss component" (walls, windows, ventilation) to the overall heat loss.

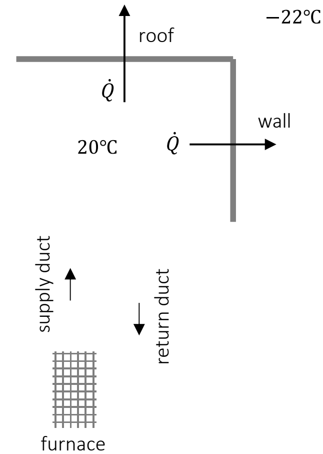
For this analysis it is sufficient to use a simple sensible fluid heating/cooling approximation with $\rho c_p \ = \ 1.23\ W/\left(\frac{L}{s} \cdot °C\right)$.

4. Consider the design of a heating system for a room that will be maintained at 20°C during cold winter conditions. The outdoor design temperature at the location is -22°C.

The room loses heat through an exterior wall (30 m^2) and roof (35 m^2). Assembly details are provided below. For this analysis, use nominal (1-D) U-values. Use thermal conductivities (W/m-K): 0.8 for concrete. 0.028 for XPS insulation. Use combined heat transfer coefficients (W/m^2-K): 10 for indoor surfaces, 25 for outdoor surfaces.







a) Estimate the total heat loss rate at the design condition (W).

b) Say the furnace draws air from the room at 20°C and delivers heated air back to the room at 45°C. Estimate the air flow rate (L/s) needed to deliver sufficient heat to maintain the room temperature at 20°C. Assume the mass flow rates are the same in both ducts. For this analysis it is sufficient to use a simple sensible fluid heating/cooling approximation with $\rho c_p = 1.23\ W/\left(\frac{L}{s}\cdot °C\right)$.

5. Air at 38°C, 30% RH is cooled to 13°C, 100% RH. How much moisture condenses per kilogram of dry air? What cooling rate is required per kilogram of dry air?

6. A gas furnace provides 25 kW of heat output with airflow 700 L/s heated from an inlet condition of 18°C, RH=45%. Identify the outlet condition (T and RH%) using a psychrometric chart.

7. Consider the adiabatic mixing to two air streams. One stream enters at 32°C and 40% RH at the rate of 20 m^3/min. The other enters at 12°C and 90% RH at the rate of 25 m^3/min. The process takes place at a barometric pressure of 1 atm. Determine the temperature and RH% of the mixture.