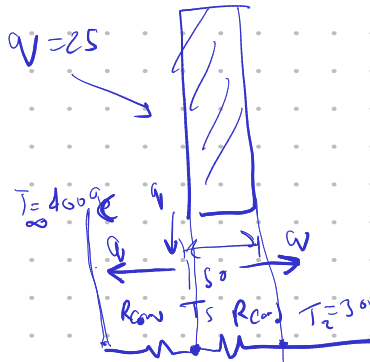


WALL

4. Concrete of normal strength loses about 75% of its strength at approximately 600°C and explosive spalling can occur in high strength concrete between 350°C and 600°C. Both effects can lead to structural collapse during fires. The walls of a room experiencing a fire may receive radiant flux of 25 kW/m² from the fire. Also convection transfers heat to the wall at fire side since the air temperature is 400°C and h = 200 W/m².K. Consider steady state conditions for a 150 mm thick concrete wall whose exterior temperature is 300°C. Calculate the temperature at the fire side surface of the wall and comment on whether the wall is likely to experience structural collapse under these conditions or not.

$$q = \frac{T_s - T_{\infty}}{R_{conv}} + \frac{T_s - T_2}{R_{cond}} + \frac{T_{\infty} - T_s}{R_{conv}} + \frac{T_2 - T_s}{R_{cond}}$$



$$\frac{1}{hA}$$

$$\frac{L}{kA}$$

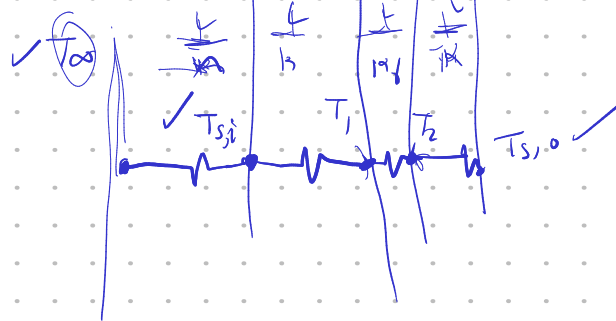
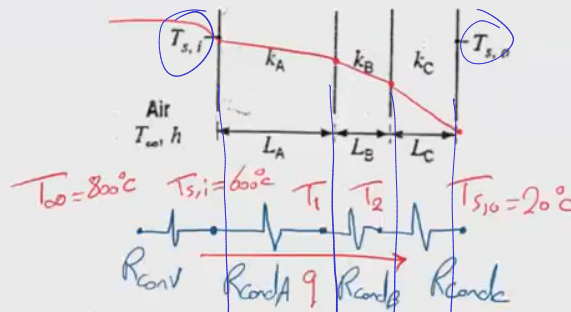
or $T_s > T_2$

$T_s > T_{\infty}$

→ heat



5. The composite wall of an oven consists of three materials two of which are of known thermal conductivity, $k_A = 20$ W/m.K and $k_C = 50$ W/m.K and their thicknesses are: $L_A = 0.3$ m and $L_C = 0.15$ m. The third material B which is sandwiched between materials A and C is of known thickness, $L_B = 0.15$ m but unknown thermal conductivity k_B . $T_{s,o} = 20$ °C and the inner surface temperature $T_{s,i} = 600$ °C and the oven air temperature $T_{\infty} = 800$ °C. The inside convection coefficient h is 25 W/m².K. What is the value of k_B . Also calculate the rate of heat transfer per unit area of that oven.



$$\frac{L}{k}$$

7. Some under graduate students at a university have rented a house in which the windows are of single pane construction. One of the students is an engineer and like all good engineers wishes to conserve energy and save money from fuel savings. She therefore proposed that winter heat losses can be reduced by covering the windows with a polystyrene insulation ($k_{ins} = 0.027 \text{ W/m.K}$) during the evening hours. To estimate the energy savings consider application of 25 mm thick insulation panels to 6mm thick windows ($k_g = 1.4 \text{ W/m.K}$). The contact resistance between the glass and the insulation may be approximated as $R''_{tc} = 0.002 \text{ (m}^2\text{K/W)}$, while the convection coefficient at the outer surface of the windows is $h_o = 20 \text{ W/m}^2\text{K}$. With the insulation at the inner surface $h_i = 2 \text{ W/m}^2\text{K}$ while without insulation $h_i = 5 \text{ W/m}^2\text{K}$. Calculate the percentage reduction in heat loss when using the insulation. If the total surface area of the windows in the house was $A_s = 12 \text{ m}^2$, what are the heat losses associated with the insulated and uninsulated window for interior and exterior air temperatures of $T_{in} = 20^\circ\text{C}$ and $T_{out} = -12^\circ\text{C}$. If the house is heated by a gas furnace operating at an efficiency of $\eta_f = 0.8$ and natural gas is priced at 0.2 P.T. per MJ, what is the daily savings associated with covering the windows

$R = \frac{L}{kA}$
 $\frac{1}{hA}$
 $\frac{L}{kA}$
 $\frac{1}{hA}$

$T_{in} = 20^\circ\text{C}$
 $T_{out} = -12^\circ\text{C}$

$A = 12 \text{ m}^2$

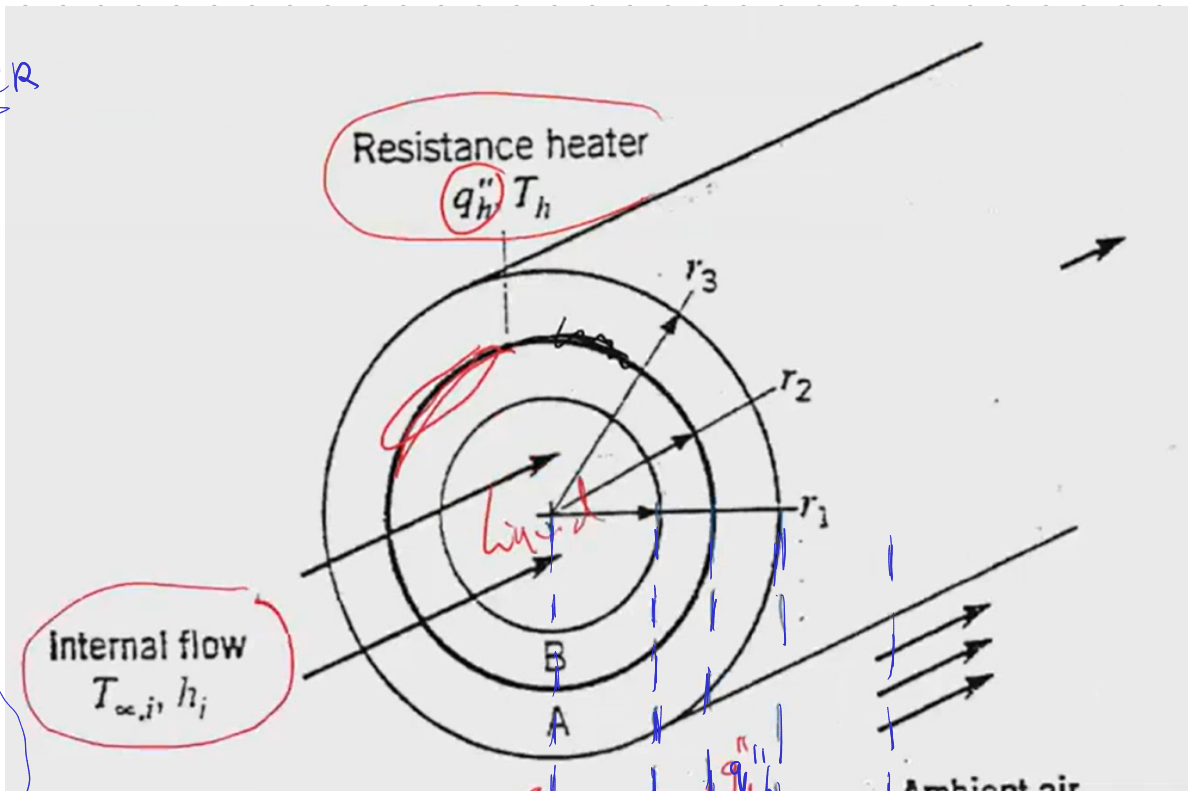
$Q = \frac{T_{in} - T_{out}}{\sum R}$

$R_{conv}, R_1, R_{ins}, R_2, R_{tc}$

$Q = Q - Q$

$\frac{Q}{2} \times 12 \times 3600 / 10^6 \times 0.2 = \checkmark$

CYLINDER



\parallel → Unit Area
 \perp → Unit length

$$q''_h = q''_i + q''_o$$

$$q''_i = \frac{T_h - T_{\infty,i}}{R_i + R_B}$$

$$q''_o = \frac{T_h - T_{\infty,o}}{R_A + R_o}$$

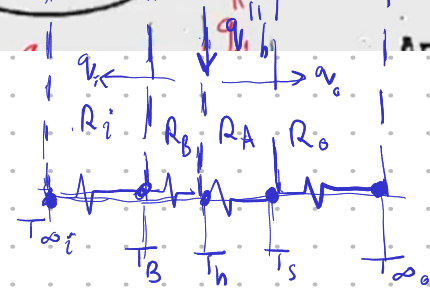
$$R_i = \frac{1}{h_i A}$$

$$R_B = \frac{\ln\left(\frac{r_2}{r_1}\right)}{2\pi k_s H}$$



$$A = 2\pi r L$$

$$q''_h \times A \rightarrow q''_h$$



13. Super heated steam at 575°C is routed from a boiler to the turbine of an electric power plant through steel tubes ($k=35 \text{ W/m.K}$) of 300 mm inner diameter and 30 mm wall thickness. To reduce heat loss to the surroundings and to maintain a safe to touch outer surface temperature, a layer of calcium silicate insulation ($k = 0.1 \text{ W/m.K}$) is applied to the tubes. The surrounding air in the power plant is at 27°C . Assuming that the inner surface temperature of the steel tube corresponds to that of the steam. The outer convection coefficient is $6 \text{ W/m}^2.\text{K}$. Calculate the minimum insulation thickness required to make sure that the outer surface of insulation material does not exceed 50°C . Also calculate the amount of heat loss per meter length of the tube.

